Frontispiece to D. J. F. Henkels History of Pyrites.



The Explanation after the Title

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The Explanation after the Title

PYRITOLOGIA:

OR, A

HISTORY

OF THE

PYRITES,

THE

Principal BODY in the MINERAL KINGDOM.

In which are conſidered its Names, Species, Beds, and Origin; its Iron, Copper, unmetallic Earth, Sulphur, Arſenic, Silver, Gold, original Particles, Vitriol, and Uſe in ſmelting.

The whole compiled from a Collection of Samples; from viſiting Mines; from an intercourſe and Correſpondence with Naturaliſts and Miners; but chiefly from a Courſe of Chymical Enquiries.

With a PREFACE, containing an Account of the Advantages ariſing from Mine-works in general, and particular from thoſe of *Saxony*.

Tranſlated from the *German* of

J. F. HENCKEL,

Late chief Director of the Mines at *Friberg* in *Saxony*.

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Jos: Banks

An EXPLICATION of the FRONTISPIECE.

1. IS exhibited a ſulphur hut, with the reverberating furnace and retorts, in which the ſulphur is driven or forced out of the Pyrites.

2. In the vitriol hut is repreſented the leaden pan, in which the vitriol is boiled out of the Pyrites, together with a waſhing trough.

3. In the third hut, the deſulphurated Pyrites is lixiviated, and prepared for making vitriol.

4. In the arſenic hut ſtands the reverberating furnace, with the diſhes and ſubliming veſſels out of which the arſenic is forced.

5. A coe or hut over the mouth of the ſhaft.

6. The mouth of a level.

7. A ſhaft, with the windlaſs, all having a relation to mining.

And as hot baths, vulcano's and whirlpools, derive their matter from Pyrites and ſulphur, ſomething about them is alſo exhibited.

ADVERTISEMENT.

DR. Henckel's book on the Pyrites is in the higheſt eſteem with all lovers of mineralogy; both, on account of the ſubject; a leading body in the mineral kingdom, analyſed into its conſtituent parts; with the uſe and importance of theſe parts at the ſame time fully diſplayed: and on account of the method of treating it; as a pattern worthy of copying after in our enquiries into nature, and a juſt ſpecimen of the method of induction.

Nor is the whole leſs inſtructively interſperſed with ſeveral fine and important obſervations in mineralogy, chymiſtry, aſſaying and ſmelting.

A tranſlation, therefore, of ſo uſeful a book, it was hoped, would meet with a favourable reception from thoſe who are lovers of a ſolid knowledge of nature, the genuine reſult of obſervation and experiment.

Dr. Henckel, however, though in other reſpects ſo excellent an author, is certainly but an indif-

ferent writer; diffuſe to a fault, and generally very obſcure and perplex in his manner of writing; with reſpect to which he has here been attempted to be abridged, cleared up, and unfolded: but his ſtrain of low pleaſantry and affectation of learning have been entirely dropt, as quite foreign, and conſequently without any detriment to the ſubject.

Where the author, in the courſe of the work, has omitted to explain a term of art; or, where any particular circumſtance ſeemed to require a further illuſtration, a note has been added at the bottom of the page, in order to render the book as intelligible as poſſible.

With reſpect to this tranſlation, much of the accuracy thereof is owing to a gentleman of uncommon eminence in this ſort of knowledge, who was pleaſed to take upon him the reviſal of the ſheets.

THE

THE
Author's PREFACE.

THE following particulars ſerving to ſhew the advantages accruing from the buſineſs of mining, both to the public, and to particular perſons, may not be altogether unacceptable to the reader. As,

1. That the chronicles of Friberg and Miſnia furniſh us with extraordinary accounts of conſiderable *tenths* and profits, conſequently of the great advantages ariſing from the Miſnian mines, both to the prince and undertakers. In particular, that Henry the Illuſtrious, marckgrave of Miſnia, had in the 13th century, from the mines of Friberg and Schneeberg alone, procured ſo many *tons of gold* * in ſilver, as enabled him to purchaſe the king-

* A ton of gold is a method of reckoning money by; which in a country reckoning by dollars or florins, amounts to 100000 dollars or florins, &c.

kingdom of Bohemia *. Further, that the weekly *tenths* from Friberg alone amounted in the fourteenth century, to 5000 rix-dollars, making in all a yearly income of 260,000 rix-dollars. The profits, therefore, to the adventurers, which amount to nine times as much, muſt have been 30 *tons of gold* †. And though ores may riſe and fall in value, they notwithſtanding yield a conſiderable income ſtill.

From 1529, to 1630, a period of one hundred years, when the ſchedules were firſt publiſhed, the profits to the adventurers from Friberg alone, amounted to thirty ſeven *tons of gold*. At Schneeberg, from 1470 to 1510, a period of forty years, to forty *tons of gold*. At Anneberg, from 1496 to 1626, a term of one hundred and thirty years, to thirty ſeven *tons of gold*. At Marienberg, from 1520 to 1627, a ſpace of one hundred and ſix years, to twenty four *tons of gold*. So that within the compaſs of one hundred years, taking one place with another, the total amount will come to ſeveral millions: and then it would be no difficult matter to make a calculus of the *tenths*, mintage, *&c.* falling to the ſhare of the prince.

From an old written abſtract it appears, that from 1590 to 1626, a ſpace of thirty ſix years, the

* Meiſniſche Berg-chronicke, p. 35.
† Freybergiſche chronicke, p. 431.

the *tenths*, the mintage, the duties from the huts, from the works of draining § and battery †, after deducting the profits for the adventurers, come to above twenty four *tons of gold*, and thus to a yearly income for the prince of almoſt a *ton of gold*. Whence we may eaſily ſee what the profits to the undertakers were. From 1603 to 1622, a period of nineteen years, the ſmelting huts of Friberg brought in to the electoral chamber above 100000 florins: the works of battery, and the duty on coals and wood in the territory of Schwartzenberg, from 1590 to 1620, a ſpace of thirty years, above 150000 florins: the cobald and ſmalt works, from 1611 to 1623, above 100000 florins: the mintage of the burnt or fined ſilver of Friberg, from 1620 to 1623, and thus for three years only, above 800000 florins: the mintage at Anneberg, Marienberg and Schneeberg, after a deduction of the profits, for thoſe three years, above 60000 florins.

And did we conſider each groove and mine apart, many of them would be found to yield the like princely, nay royal income. To inſtance only

§ Draining at the huts, is the operation of ſeparating the ſilver from the black copper, or the ſort not quite freed of its ſulphur, and other impurities. It is performed by ſmelting together a quantity of black copper and lead, and tapping them off into round cakes, which being ſet edgewiſe in a peculiar furnace, and expoſed to a gentle fire, ſuffer the lead, carrying along with it the ſilver in the black copper, to drain or trickle from them, leaving the copper honey combed and ſpongy.

† The operation of beating out iron into bars and plates.

only in the ſixteenth century: It appears by the Friberg chronicle *, there were above one hundred ſuch works, which yielded quarterly, in profits to the adventurers, for one mine-action (according to the then diviſion into thirty two ſhares) at the leaſt ten; moſt of them above thirty and forty; many above fifty and one hundred; nay, ſome, above two hundred; and the Thurnhoff and Hohebircke in particular, above three hundred rix-dollars. And this we ſhould well obſerve, as it ſhews, that not only one or two mines, are thus valuable, but generally all of them; and obviates an objection, as if all theſe treaſures were now quite exhauſted: which is far from being the caſe; our hopes being ſtill as extenſive, as there are grooves and mines to work, and *field* for receiving ſuch a vaſt number of ſhafts and levels †: not to mention entire, *unmeaſured* veins, which are ſo much freſh and unoccupied treaſure.

Further, the accounts and inſtances we have of extraordinary rich ores in ſome works, ſhould prevail with us to view the buſineſs of mining with other eyes than we commonly do. At Schneeberg in 1478, a rich ſilver vein was diſ-

* P. 434. † Shafts are pits, ſometimes perpendicular, ſometimes oblique, ſunk upon a vein. Levels are horizontal paſſages worked thro' a mountain, both for draining the mine of its water, landing the ore to the day, and for conveying in air. And for both theſe laſt uſes ſhafts alſo ſerve.

diſcovered, and ſo large a wedge or block of ore, and native ſilver laid bare, that duke Albert of Saxony went in perſon down into the groove, and uſed this huge block, which ſmelted four hundred centners of ſilver, as a table to dine on *. And tho' ſuch huge maſſes are uncommon, yet it is not unfrequent to ſee expoſed at once, even within a narrow compaſs, large quantities of ore, as might, were a calculus made, come to ſeveral centners in ſilver. For not to mention maſſes of native ſilver, and of *glaſſy* and *red-goldiſh* ores, we find, at the proper depths, large veins of *lead-glitter*, or galena and the like ores. Nor is it at this day unuſual at Schneeberg, Johan-Georgen-ſtadt, Ehrenfriedersdorff, and the like noble mines, to diſcover whole neſts of native ſilver, *glaſſy* and *red-goldiſh* ores, delivered into the ſmelting-huts by centners †.

2. That mines, as we have ſeen, conſtitute not the leaſt, nay rather the principal branch of a prince's revenue, when once they are brought to bear, and have a proper demand on them; the tenths alone making no inconſiderable part thereof.

3. That the advantages, indirectly or mediately, accruing to a ſtate from mines are very great: in that they ſerve to ſupport and increaſe the num-

* Albini Meiſsniſche Berg-chronicke, p. 30.
† The mine-centner is reckoned at 110 lb.

number of inhabitants, afford the materials for trade and manufactures: and what we ſhould principally here conſider, the conſumption of home and inland commodities, all yielding duties and taxes: by which means at leaſt money comes to circulate longer in the country, and not fall into hands, that either hoard it up, or ſend it abroad for commodities, we may well be without. And it muſt be a ſtanding proof of the value of mines to a country, when we read of whole cities and towns being built by their means: as it is to them alone, that Friberg, one of the moſt conſiderable in Saxony, owes its riſe and preſent flouriſhing ſtate, being, no earlier than the thirteenth century, but a poor deſpicable village, ſtill conſtituting the moſt inconſiderable part of the town at preſent, and called the Saxon-town. Schneeberg, which comes next to Friberg; nay, all the mine-towns in general, owe their riſe to mines. And Johan-George-ſtadt, founded by the elector John-George, 1. is a peculiar inſtance, that our country, even in latter times, is as capable as ever of having its mine-works improved, and brought to a flouriſhing ſtate.

4. That the buſineſs of mining has, in our country at leaſt, no ſmall degree of preheminence above all others of what denomination ſoever. There is not a greater demand for any one thing than for the produce of mines; and yet nothing is rarer in any country. No country is without manufac-

nufactures; but many, without mines; moſt without ſerviceable ores; many, eſpecially on the ſcore of ſituation, ſcarcity of wood and water, unfit for carrying on the buſineſs of mining. In a word, mines are, as it were, a privilege peculiarly beſtowed on ſome countries, excluſive of others, and therefore to be highly eſteemed. But to conclude, what are all the ſubjects of the grand manufactures in Miſnia other than thoſe ſupplied us by mines? For inſtance, the famous ſmalt-work at Schneeberg, which has yielded ſo many millions both to the prince and adventurers, is no where in the world to be matched, and conſequently to be deemed a peculiar treaſure. Our ſalt-ſprings too are a kind of mines. Tin is a metal become very neceſſary in common life, and yet, in ſome meaſure, the rareſt of all others. There are but few tin-mines in Germany; nay, in reſpect of other metals, few in Europe. All in Germany, as far as I know, are thoſe in Miſnia, Bohemia, and Carinthia, and formerly in the Fichtelberg at Wonſiedel. Whole kingdoms, as Sweden, Denmark, Norway, &c. have no ſuch mines, but are obliged to be ſupplied with tin from England: and all Germany, from Miſnia, Bohemia, and England too.

5. That our Miſnian mines in particular have by far the preference to all others in Germany. Two things, namely *levels* and wood, are indiſpenſibly

Penſibly neceſſary for carrying on a mine-work. The former, in order duly to reach home to the proper depth, and through ſuch ſubterraneous canals to drain off the water into a valley; in order thus to ſuperſede the uſe of expenſive engines. The latter, in order not only to timber and ſecure, where needful, the *ſhafts* and *drifts* *, but alſo ſmelt and work the ores for their metal. Now, as to *levels*, our forefathers have, for inſtance at Friberg, left us ſuch extraordinary works in this kind, as that, in want of them, our mines would become quite impracticable; particularly that called the *prince's level*, one of the grandeſt works in theſe parts, conſidering the time, labour and expence neceſſary to work a paſſage under ground through firm rock, for about five Engliſh miles in length. As to *wood*, the want of that in particular diſqualifies many places for mining. The expences at the *day* in aqueducts, trenches, ſtamping and waſh works, in engines, in conſtructing the ſmelting and other huts, in wooden trunks, good *additions* † or fluxes, ſerviceable *ſlags* or ſcoriæ, &c. Things abſolutely neceſſary in the buſineſs of ſmelting, come very high in ſome places, but not ſo in Miſnia. Nor muſt I omit mentioning to our honour, that both for

* Drifts are horizontal paſſages, much in the nature of levels deſigned either for going upon a vein, and digging out the ore; for conveying off the water, or for conveying the ore to its place of collection, or the bottom of the ſhaft.

† By additions ſmelters mean thoſe matters added to their ores, in order to procure their yield, or to work them to better advantage.

for the buſineſs of mining and that of ſmelting, we have the ableſt, moſt experienced and ingenious artiſts in the whole world: nor this other conſiderable advantage, peculiarly our own; namely, the variety of our ores, than which nothing is more ſerviceable in the buſineſs of ſmelting: as by properly doſing and mixing theſe together; we are able to work to better advantage what would otherwiſe remain unſmelted, and be forced off among the *ſlags*. And who could ever have imagined, that *red-goldiſh*, and the like rich ores, ſhould fail to ſmelt, if not worked with *pyrites*? And yet this is what for ſome years paſt our neighbours at Nicolasmine in Bohemia have ſufficiently experienced: whence they are obliged, at much expence and labour, to be ſupplied with the *pyrites* from us; in order previouſly to *crude-work* their poor, *quartzy* ores: that is, ſmelt them crude along with deſulphurated *pyrites*.

My view in all this is to ſhew of what conſequence the knowledge of ores, or the buſineſs of mineralogy is as a foundation for thoſe of mining and ſmelting: and that a very ſerviceable, important ſubject is the matter of my preſent enquiry.

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PYRITOLOGIA:

OR, A

HISTORY

OF THE

PYRITES.

CHAP. I.

The Subject propounded, with the Manner of treating it, *&c.*

AT length appears this promiſed hiſtory of the *pyrites*. And conſidering the length of time I have been employed in it, many of my readers might, perhaps, expect a larger work on the ſubject, and to have had it ſooner. To ſuch I offer the following reaſons by way of apology.

1. A multiplicity of avocations: my ſtation and circumſtances in life being ſuch, that many times for half a year together I have not been able to beſtow ſo much as a ſingle hour upon

the ſubject, either as a chemical operator, or as a writer. Tho' indeed, to be ingenuous, ſomething of diſguſt and indifference interpoſed; as generally is the caſe in a work of conſiderable length, and carried on amidſt a diſſipation of thought. Nevertheleſs, ſuch as it is, I have ſpent ſo much time and been at ſo great expence in this performance, that I know not whether, under the ſame circumſtances, I ſhould ever again be able to execute ſuch another.

2. The importance of the ſubject: more than a little time was required to procure from the ſeveral countries and mines their ſeveral ſpecies or ſamples; and the Engliſh ſamples, diſpatched for me by the celebrated Dr. Woodward, never came to hand. A repetition of ſome experiments was alſo neceſſary, eſpecially to determine the very ſlow vitrioliſation of ſeveral ſorts of *pyrites*, further to confirm my opinion of this mineral body, and to procure the remarks and ſentiments of my correſpondents concerning it.

3. My method of treating the ſubject: it was not my intention to fill up my book with tranſcripts from authors. Nor indeed had I ever ſo great a mind to it, could I well; ſeeing nothing uſeful to my purpoſe could be found in them.

But is it readily to be imagined, that the treating a ſubject in the laboratory, and the diſcovering a new truth, ſhall require no more time than the writing over a few leaves of paper? I may truly aver, there is many a truth and many a very ſhort propoſition, which I was obliged to retain in my thoughts, through the courſe of this enquiry, as it were in labour, to bring them to the birth, here ſet down in the compaſs of a few lines, that employed me not only days and weeks, but even months to aſcertain. And yet, after all, ſome others remain behind,

on

on which I might have ſpent a great many years, or even my whole life, and not be able at laſt to place them in a clear light, and free from every objection.

One of my views in this undertaking was to ſet a pattern to others, who may happen to have better helps, than I can well challenge, to proſecute this ſubject to a greater length. Another, to engage the attention of mankind in the ſtudy of nature: a ſolid and uſeful knowledge of which is rather to be hoped for in this manner, than from the books commonly wrote on the ſubject. But from this track we are generally diverted, either by our preſent method of education, conſiſting for the moſt part in learning the application of lines and angles, as the neareſt ſtep towards the attainment of the knowledge of bodies, whereby we entirely diſregard the ſtudy of nature in herſelf; that is, in the forms, mixtures, and qualities of bodies; tho' by far the moſt important and uſeful. Or, thro' a remarkable degree of indolence, notwithſtanding the pleaſure attending the purſuit, chuſe to forego the trouble, generally accompanying the making proper experiments and obſervations; eſpecially proceſſes by fire, where every circumſtance is to be regiſtered, or ſet down with the greateſt care, and accompanied with proper remarks. Nay, where a ſingle over-ſight, the ſpringing of a glaſs, or even a groundleſs ſcruple, after the proof or trial is over, may occaſion the repetition of an experiment, perhaps, ſeveral times. Tho' this very trouble is abundantly compenſated, by the ſolid knowledge and experience we derive from thence to ourſelves: hereby we have a lively and clear conception of things, in caſes where books prove uſeleſs, nay fallacious; and are enabled to pronounce with boldneſs and certainty concern-

ing the truth or falſhood of any propoſition. Nay, even the very noting down the ſeveral circumſtances of a proceſs muſt be advantageous, by affording a conſtant directory for repeating the experiments afterwards, without any fear of a miſcarriage: and the comparing one truth or axiom with another, cannot fail to yield us juſt and ſolid concluſions, as well as the beſt materials for laying the foundation of a ſolid natural knowledge.

A principal motive to the preſent undertaking, in which I could wiſh to be imitated, is the improvement of natural hiſtory. A perſon, converſant with things, and not with books only, muſt needs experience the inſufficiency of our preſent philoſophy, and how few ſubjects are treated by writers with accuracy and preciſion enough, to give full ſatisfaction to an inquiſitive mind. Inſtances of their negligence, in this reſpect, are every where obvious; but no where more ſo, than on the ſubject of the *pyrites*; no one author having hitherto ſupplied us with any clear deſcription, or tolerably accurate diſtinction of this important and leading mineral body. I ſay not this merely with a view to find fault, being rather inclined to commend the care and diligence of thoſe, who have gone before me: nor do I preſume to ſet up my own performance for faultleſs and finiſhed; but to expoſe the indolent methods of thoſe writers of our days, who content themſelves with being mere tranſcribers. In our enquiries after truth, we ought to uſe a freedom and openneſs in animadverting upon the imperfection of our knowledge: Nor ſhould we ſtop ſhort with the ancients; but taking up one body after another, conſider each with due attention and leiſure, and thus collect materials for lateſt poſterity to work upon, and therewith

with raiſe better ſyſtems than we are at preſent poſſeſſed of.

Of what conſequence chemical enquiries into nature may be, will appear from ſome diſcoveries I have accidentally made, in my examination of the *pyrites*; from which, and a certain kind of earth, each ſeparately barren of ſilver, I procured an actual ſilver: alſo from *pyrites* itſelf, a ſteel tincture peculiarly ſweet, and without that roughneſs, common to ſuch tinctures; alſo from my enquiries into the nature of the *pyrites*, I have gained no ſmall degree of knowledge in the buſineſs of ſmelting ores.

As to my method of procedure in the preſent enquiry; I have, in the firſt place, laid it down for a rule to myſelf, to abide ſtrictly by matters of fact, without giving into any hypotheſis or empty ſpeculation whatever; and, therefore, I attempt not to ſeparate or reſolve the *pyrites*, either into the four elements, the three, or other imaginary principles; as being things that can never be made objects of our ſenſes; or that any one can ſo explain, as to convince an impartial enquirer, that theſe are the eſſential conſtituent parts of our ſubject: a rule as indiſpenſibly neceſſary, as it is generally but little regarded. 2. I have put the *pyrites* to ſeveral accidental proofs, and by that means often diſcovered, what I otherwiſe could never have hoped for. That from the acid vitriolic-ſalt, and the alcaline earth of the herb Kali or Soda, a blue colour ſhould be procurable, is what no one could beforehand ſuſpect: as little, as that the *pyrites* ſhould yield a ſweet iron-tincture; or, that a ſpecies of earth, in itſelf deſtitute of ſilver, ſhould, by means of the *pyrites*, become remarkably ſilvery. 3. I never ſcrupled ſeveral times to repeat a ſingle experiment; either up-

on the breaking of a veſſel, or other failure in the courſe of the proceſs. 4. I have uſed the greateſt care in chuſing and ſeparating the ſeveral matters employed; a circumſtance of no ſmall importance; for, not to mention the various ſorts of ſolvents, ſalts, *&c.* (which notwithſtanding are to be well examined in reſpect to their goodneſs; ſo as we may be able to diſtinguiſh, for inſtance, between alcali and alcali, ſalt of tartar and potaſh) we muſt be careful, knowingly not to employ for proof any communicative *additions*, but the bare *pyrites* alone. The ſeveral ſamples employed, were ſuch as I either originally procured myſelf, or had from perſons of credit and veracity. Theſe I carefully examined and ſeparated from each foreign admixture: which was found needful, even when externally they ſeemed to give no ſuch ſuſpicion; as is plain from the *ſteely* or cloſe *pyrites* of Pretzſcendorff; having experienced the ſeemingly pureſt ſort of them, to be not only internally full of fiſſures, or fibres, but theſe fiſſures to be often mock-leady, and thus apt to miſguide or at leaſt to puzzle the moſt careful operator. And the *pyrites-kidnies* of Franckenberg, how cloſe ſoever they may ſeem externally, and how ſimilar ſoever, internally, yet ſhew not only a black mock-leady impurity, but alſo ſuch interſperſed pieces of *copper-pyrites*, as are evidently diſtinguiſhable from the reſt of the ſample, namely, the genuine *iron-pyrites*. 5. A no leſs degree of care I uſed with regard to the veſſels and inſtruments, employed in making the experiments: a caution of greater importance than the unexperienced may imagine. The colours manifeſting themſelves in experiments, ſhew much of the internal nature of bodies, and their productions: or, at leaſt, how one ſort comes to differ from another; and are of ſo peculiar a nature,

as

as that a ſingle drop of a foreign liquor, or the leaſt grain of a ſalt, or ſmut, ſhall change them: and therefore, to procure ſuch as are beautiful, the greateſt nicety and care are to be uſed, as in this caſe, having to deal with one of the moſt delicate ſubjects in nature. Nay, mixtures themſelves come out very different, without the greateſt care be had to make perfectly clean a veſſel once uſed, or to employ a new one; a little common ſalt, or ſal ammoniac, directly adulterating aqua fortis; the leaſt quantity of a contrary ſalt marring an intended fermentation; and a lixivious ſalt, which has conceived only a little acid from the air, becoming unfit for the mercurification of metals, as well as for other proceſſes. And in the buſineſs of aſſaying, there may ſomething, which may ſerve to falſify a proof, ſtick to the ore-diſh, or to the hammer, wherewith the proofs are rubbed, or even to the hare's foot. And in the deſulphuration of the *pyrites*, we might, without uſing new retorts, nay, even new receivers, eaſily be impoſed upon, or at leaſt, not ſo certainly obſerve what *pyrites* are, and are not, arſenical: as the arſenical impurity may unobſervedly lodge in retorts and receivers, not ſufficiently cleared thereof; nor will the fetid arſenical ſmell, very ſoon wear off; whence alſo the weight of what paſſed over, and what remained behind, cannot always be taken with a neceſſary exactneſs; a circumſtance, to be well obſerved. 6. Another direction of moment, is the accurately entering the ſeveral experiments into a particular journal; the numbering the ſeveral glaſſes, boxes and caſes, for holding the different matters to be worked, and the ſeveral productions procured; either for a farther examination, or future uſe.

And though the *pyrites* be a mineral ſo very common, that there is ſcarce any earth, ſtone,

fibre or vein without it, and of ſuch extenſive uſefulneſs, ſupplying us with ſulphur, arſenic and vitriol, thoſe capital inſtruments both in nature and chemiſtry, and with one of the moſt powerful fluxes (eſpecially with us in Germany) for forcing ſtubborn ores to give forth their contents; yet its nature is hitherto ſo little underſtood, and all the accounts we have of it are ſo very lame, no one having either clearly deſcribed, or accurately diſtinguiſhed it, that an attempt to put it in its proper light ſhould ſeem to want no apology.

But to give the reader a ſtill nearer view of my manner of managing this ſubject: I have examined upwards of 60 different ſamples of *pyrites*, procured from different parts; conſidered each ſample apart in its colour, texture, and ſpecific gravity; expoſed a little of each to the air, in order to diſcover which ſort would, and which would not, be affected and opened by it; to the fire, for its contents; to the action of the magnet for its iron, both in the crude and calcined ſtate of the ſample; to aqua fortis and aqua regia, for the gold and ſilver; nay, to vinegar and ſpirit of ſal ammoniac, for diſcovering the copper in it: ſome ſamples I have boiled with alcaline lixiviums, with lixiviums of common ſalt and allum; the one to ſeparate the ſulphur from its metallic earth, and form a *hepar ſulphuris*; the other, for the vitriol acid to lay hold on the alcaline earth, and diſcharge the acid of the common ſalt; conſequently to exhibit an Epſom, or the like ſalt of a mineral water, or a Glauber ſalt; and thus to ſerve to eſtabliſh my conjectures on the original of *acidulæ*. I have combined the ſeveral parts of the *pyrites* with each other, and with other bodies; nay, the entire *pyrites* itſelf. I have examined the *capita mortua* of the *pyrites*, in the ſame manner as the *pyrites* itſelf: in particular, I have mixed

the *pyrites*; ſometimes with ſal ammoniac, whereby I have procured the ſaffron iron-flowers; ſometimes I examined it by detonation with ſalt-petre, in order to find out the different proportions of its inflammable earth: and laſtly, took a great deal of pains in aſſaying it, by employing, as *additions*, various ſorts of earths and ſtones.

Volcanos and *Thermæ*, are, in a great meaſure, owing to the effects produced by the *pyrites* in the bowels of the earth. As it is well known that iron and ſulphur perfectly, and with eaſe, take fire along with water. By means of theſe it was, that the elder *Lemery* attempted, in the ſmall way of experiment, to imitate the effects of volcanos and earthquakes. And for this purpoſe he ground iron and ſulphur, which, with water, he made into a paſte; which, after ſtanding for two or three hours in the open air, began, without any application of fire, to grow remarkably warm, then hot, at length to heave and ferment; and thus the maſs, in ſeveral places up and down its ſurface, came to have ſeveral cracks and rents, thro' which there tranſpired a fume, which proves only warm in ſmaller, but actually takes fire in larger maſſes, as of thirty or forty pounds. From this experiment he attempted to account for the burnings of *Veſuvius*, *Ætna*, *&c.* And with that view he proceeded as follows. "I put, ſays he, "ſome of this mixture of iron and ſulphur, both in-"to larger and ſmaller, and into taller, narrower "pots; and the matters, as lying there more "cloſe and confined than in earthen diſhes, be-"came more violently heated and heaving, and "in part ſprung out of the pot. Further, in "ſummer-weather I filled a large pot with fifty "pounds of this matter, and covering the pot "with a linnen-cloth, buried it about a foot deep

"in

" in a hole in the earth, and covered all with " earth. In about eight or nine hours after, the " earth beginning to heave, heat and ſpring up, " there burſt out a ſulphureous hot fume and an " actual flame, which enlarged the rents, and a " yellow black powder ſettled ſuperficially round " about them. The earth remained a long time " warm: and when I came, after this, to dig " out the pot, I found remaining only a black heavy " powder, *&c.* This proceſs ſucceeds better in " ſummer than winter, as the ſun's heat may " be ſuppoſed to have a better effect on the ſul- " phur and iron." He then proceeds to obviate ſome objections. As, 1. Whence volcanos come to have their air, without which there can never happen any accenſion. 2. How amidſt much moiſture, as the water of the clouds, the matter of thunder and lightning, ſhould come to take fire: as to the firſt, 'tis eaſy, ſays he, to conceive that the earth, a porous, permeable body, is equally filled, as it is invironed, with air. The ſecond he endeavours to explain by means of that experiment, where, in making iron-vitriol with the acid of vitriol and common water, the fumes ariſing from the glaſs body take fire, and burſt out into actual flame, by approaching a candle to them, as though they were ſpirit of wine, notwithſtanding theſe inflammable ſulphur-particles are envelop'd in water *.

Laſtly, As to *Thermæ*, or hot ſprings, I imagine no one, acquainted but ſuperficially with their internal conſtitution and nature, will call in queſtion their partial orgination from the yellowiſh or ſulphur-iron *pyrites*; I ſay *partial*, and not *total* origination; in regard that theſe, in particular the *acidulæ*, as the *Caroline*, *&c.* carry along with

* Mem. de l'Acad. Roy. l'ann. 1700, p. 131. *Seqq.*

with them ſome highly predominant and capital matters, namely, a lixivious ſalt, and a calcarious earth, which cannot be ſuppoſed to be derived from any one ſort of *pyrites*; but probably, if not from common ſalt, from lime-ſtone; and if not from this laſt, from ſpad, which is a calcarious ſort of ſtone; and if not from ſpad, from ſo fatty an earth and ſtone, as that from which the aluminous lime-earth is generated. For, who is not convinced that theſe ſprings generally contain ſomething vitriolic, which remaining untouched by the lixivious ſalt, exhibits a formal vitriol; or, in other words, its acid ſalt may be made to ſeparate from the alcali; and thus form a bitter ſpring-ſalt, its metallic earth falling as an ochre to the bottom. And ſulphur itſelf formally efflores̄ces about ſuch mineral ſprings, as thoſe of *Aix-la-Chapelle* in particular. Now ſulphur, the vitriolic acid, and a metallic ochre, are parts derived from *pyrites*, and not from ſtone-coal or bitumen.

CHAP.

CHAP. II.

Of the NAMES* of the PYRITES.

IN natural hiſtory, and more eſpecially in the foſſile kingdom, fancy rather than judgement appears to have determined the names of a great variety of bodies: thus to imaginary or accidental circumſtances the *Dendritis*, *Selenites*, *Myrrhinites*, *Ætites*, *Aſtroites*, *Bufonites*, with many more, owe their reſpective denomination. With reſpect to the mineral under conſideration, its name, *pyrites*, or fire-ſtone, has, above moſt other foſſils, the good fortune to be equally juſt and expreſſive.

It is called a ſtone in the ſame ſenſe, as all ores, that are not quite ſpungy and friable, are ſo denominated from their hardneſs, weight, and cloſeneſs; for inſtance, *lapis æris*, *lapis ferri*, copper-ſtone, iron-ſtone, *&c.* however, we are not to confound it with the *horn-ſtone* [flint] which is uſed for fire-arms, and at this day commonly called by the Germans *fire-ſtone*.

Pyrites more eſpecially derives its name from fire, as it contains a larger ſhare of ſulphur, which is the *pabulum* of fire, than moſt bodies in the mineral kingdom: not indeed more than all ores, ſeeing cinnabar and antimony ores, alſo ſtone-coal, partake conſiderably of ſulphur; nevertheleſs, it claims a preference in this reſpect to all ores of a ſtoney nature, which the three abovementioned cannot be properly deemed, on account of their friability, and extreme looſe texture. In

* It is but juſtice to the author to take notice that, under this head, he has ſhewn great aſſiduity, and diſplayed more than a common ſhare of learning, in tracing the Etymologies of the ſeveral names applied to *Pyritæ*. Theſe, however curious, are apprehended not the moſt uſeful parts of this work; for which reaſon the tranſlator acknowledges that he has taken greater liberties in his abridgement of this chapter, than in any other.

In High-Dutch *pyrites* is called *kies*; whence this term is derived is not very eaſy to determine; perhaps the firſt inventor of it had in view the *kieſel*, or flint-ſtone, as *kies* and *kieſel* are ſo far analagous in that both ſtrike fire: or it may well enough be derived from *erkieſen*, to chuſe, as that ſtone or rock is, in mining, to be *choſen* before all others, where ſuch a ſulphureous vitriolic iron and copper ore offers, ſeeing the *kies* can lead the miners, as by a clue, to the wiſhed-for labyrinth of gold and ſilver veins: alſo, when two undertakers have branches of veins running together, and afterwards ſeparating, and coming out of the compaſs of the ſhare, the elder muſt *chuſe*, or pitch upon a branch, which he cannot readily do without *kies* †. But ſhould neither of theſe derivations be approved, it yet may be allowed to paſs for a venerable old German mine-term, till its genuine etymology can be aſcertained. It is at leaſt ſo common a word among Germans, that I know of no province, in which the language is ſpoke with propriety, where it is not in uſe; only with this difference, that ſome are not accuſtomed to apply it to ſuch *pyritæ* as are very coppery, or highly arſenical: for inſtance, at Friberg, the former are called copper-ore, the latter *miſſpickel*; with theſe the term *kies* is wholly dropt; while others, particularly at the Hartz, are wont to call even the richeſt copper-ore *kies*, as, *copper-kies*.

The Arabians uſe to this purpoſe the term *marcaſita*, marcaſite, which the Germans alſo have, from the Romans, in ſome meaſure, adopted. This appellative, though, ſtrictly ſpeaking, it is not, under certain circumſtances, improperly applied to the ſubject here treated of, has been made uſe of, by different authors, to denote ſuch a vaſt variety of mineral ſubſtances, as well artificial as natural,

† *Roſinus*'s Berg-bau Spiegel [Mine Mirror] i. 4. c. 4. §. 14.

natural, that it ought not to be received but with ſome caution, and under many reſtrictions. The druggiſts ſeem to underſtand by it *biſmuth*, and the alchymiſts, who indeed generally affect confuſion and obſcurity, have made it to expreſs not only *biſmuth*, but alſo *regulus of antimony*, *ſpelter*, and moſt of the known ſemi-metals. Among the mine-men, particularly thoſe of Miſnia, by *marcaſite*, according to the beſt information I could get, is meant our *pyrites*, or *kies*; not generally, but only when finely angular, ſmooth, and eſpecially of a cubical form, and of a gold-glittering caſt. On the contrary, another, though broke off from this very piece, which in the freſh break has the very ſame colour, and which affords the ſame contents, if it happens only to differ in the external figure, is not, on any account, allowed the name of *marcaſite*.

Under the like circumſtances of confuſion and ambiguity, the term *Magneſia* has been introduced into the hiſtory of the *pyrites*; particularly by alchymical writers, as Flamellus *, who gives this denomination to the *pyrites Achaiæ*; and Bohnius † uſes the ſame expreſſion (with the addition of *Vitriolata*, on account of its eaſy reſolution in the air) to denote the Heſſian iron-earth, which is a real, and indeed a firſt-rate *kies*. However, among mine-people, and in common language, the term is very little, if at all known, except with the glaſs-makers, who mean by it a martial mineral, more commonly called brown-ſtone, of a duſky colour, rather inclining to black, and ſpicular, like antimony. Its uſe in the glaſs-houſes is to give a due whiteneſs and tranſparency to the better ſort of glaſs: the potters alſo employ it in glazing their manufactures. In Italy it is known by the name of *Manganeſe*. But though the word *Magneſia* is not

* Theatr. Chym. T. IV. p. 863.
† Bohnii Diſſert. Chym. IV. p. 108.

not generally made uſe of, and has often been injudiciouſly applied, to ſignify *pyrites*, if it be conſidered, that many ſpecies of *pyritæ* powerfully attract the air, which is the moſt natural ſort of vitrioliſation, this appellation, derived from their *magnetical* quality, will not appear altogether unjuſt, or improper.

Bernh. Cæſius §, and Feſtus Pompeius, ſeem to have been deceived by appearances, and to have meant a *pyrites*, by what they have called an *Aurichalcum foſſile*, or a native foſſile braſs. Ulyſſes Aldrovandus ‖ has clearly diſcovered the miſtake of the latter; a miſtake, that nothing but a profound ignorance in mineralogy could have occaſioned.

Igniarius, *lapis luminis*, fire-ſtone, light-ſtone, are names more juſtly appropriated to *kies*, or *pyrites*; ſeeing by a ſmart ſudden ſtroke againſt ſteel, they emit ſparks of fire and light, that manifeſt themſelves by the accenſion of gunpowder, tinder, or ſuch matters. However, *pyritæ* differ in this reſpect, according to their contents; thoſe that partake moſt of copper, afford the feweſt ſparks, and by how much more they are impregnated with iron and ſulphur, the moſt; though even the white arſenical *pyrites*, or *miſſpickel*, that yields no ſulphur, will exhibit ſome fire.

From hence the Germans have given to *pyrites* the name of *Buchen-ſtein*, fire-lock-ſtone, as it was formerly uſed for fire-locks: but in order more effectually to anſwer this purpoſe, care ſhould be taken to chuſe ſuch as are the hardeſt, moſt denſe, and capable of being worked into a proper form.

Mart-

§ L. I. c. 9. p. 130.

‖ Quando Feſtus Pompeius ſcripſit *aurichalcum* in montibus naſci, proculdubio non eſt locutus de aurichalco, arte parato, quod ex ære et cadmia conficitur, ſed fortaſſis hunc *Pyritem* intellexit, qui aurichalcum perbelle æmulatur. Aldrov. Muſæum, L. VI. c. 3. p. 514.

Mart-ſtein is another denomination of *pyrites*, and far from being attended with any impropriety; as its etymology may be deduced from *Mars*, or iron, and this foſſile is principally an actual iron-ſtone.

Vulcan, the god of fire, being under great obligations to the *pyrites* for his beſt fuel, as appears from thoſe huge elaboratories in mounts Hecla, Ætna, and Veſuvius, the ſubject of our preſent enquiry has been honoured with the title of *Hephæſticus*, or *Hypeſtionus*.

As iron makes a principal part in the compoſition of the *pyrites*, *ſideritis*, σιδηρίτης, iron-ſtone is no inadequate appellation; nor, if its igneous qualities are duly attended to, can *pyropus*, *pyrobolus*, *pyrimachus*, terms uſed by ſome of the antients to ſignify the ſame thing, be thought very improper.

Othonna, according to Geſner, is a copper-coloured ore in Egypt, which Aldrovandus takes to be the ſame with *lapis luminis*, and Ariſtotle's *pyrimachus*:—*Atrament-ſtein*, or vitriol-ſtone, has alſo been numbered among the denominations of *pyrites*; but of this laſt appellation more hereafter.

Corallus, coral-ſtone ſeems to be miſapplied, when appropriated to *pyrites*, ſeeing though the rock wherein it lies is often found red, the genuine *pyrites* never exhibits that colour.

Chalco-pyrites is an uſeful diſtinction of the coppery ſort: nor is the *aſſius lapis*, or as Agricola expreſſes it, *Aſiæ lapis ſive lapis ex Aſia, ubi naſcitur ſarcophagus*; that is, where the fleſh-conſuming ſtone grows, altogether improper, as the coroſive power of vitriol is well known.

But it is high time to have done with mere names; let us proceed to what it is hoped will afford more real inſtruction, which, to the utmoſt of my ability, is intended in the ſucceeding chapters.

CHAP.

CHAP. III.

Of the ſeveral SPECIES of the PYRITES.

PYRITES, or *kies*, in the ſenſe we are to take it, is a mineral or ore, partly white-grey, partly yellowiſh grey, partly braſs-yellow; having for its conſtituent principles a metallic, namely, an iron earth, which is its proper characteriſtic; a volatile matter, as either ſulphur or arſenic, or both, tho' the former prevails more frequently; ſome ſorts are found to partake largely of copper, with which is generally found a mixture of ſilver, but in a very ſmall quantity, and ſometimes an appearance of gold, tho' this is rather imaginary. The *pyritæ* are commonly worked for ſulphur, arſenic, ſandarach and vitriol, the laſt of which ought not to be looked upon as an original principle, but as a production conſequent of the combination of the other principles.

The parts of the *pyrites* may alſo be conſidered as they are either eſſential or incidental. With reſpect to the former, there is properly in nature no more than one ſort of *pyrites*; for in all there is iron, and this iron is the primary conſtituent part; every *pyrites* being an iron earth, either ſulphurated, or arſenicated, or participating of both at the ſame time. In an incidental view, *pyrites* are diſtinguiſhed, 1. with regard to their metallic contents. 2. Their ſulphur and arſenic. The former may be divided into iron and copper *pyrites*, the denomination being here taken from what conſtitutes the greateſt part of this compoſition. At Friberg, the *copper-pyrites* denote ſuch as yield

one, two, or the like ſmall number of pounds of copper, and called at Friberg *copper-ore*. Thus were *copper-pyritæ* diſtinguiſhed by a peculiar name, whilſt the *iron-pyritæ* lay neglected, under the ſimple denomination of *pyrites*, or *ſtone-pyrites*, or *ſulphur-pyrites*, without any diſtinct appellation that ſhould denote the eſſence of it. At Friberg all ſuch are *iron pyritæ* as hold little or no copper.

That kind called *gold pyrites*, when accurately examined, as I have done all of them, proves either a highly coppery ſort, or the common *pyrites*, ſhewing externally of a beautiful gold-colour; theſe are particularly procured from Hungary, and have groundleſly raiſed extraordinary expectations. Tho' when any gold or ſilver is procured from *pyrites*, it may happen either from the ſpangles or threads of theſe metals, or from a genuine ſilver-ore being unobſervedly intermixed with the ſample under proof. Again, Men have been apt to be impoſed upon by the gold colour caſt of the ſample, whence the ancients called it *pyrites aurei coloris*. After all, the gold generally procurable by ſuch proofs is very inconſiderable; nay, what is to be met with in almoſt all mineral glebes, and in moſt, if not all ſilver, for procuring which no *pyrites* was ever particularly employed.

Much the ſame we may ſay of what is called *ſilver-pyrites*; the ſame cautions are neceſſary to prevent being deceived by the colour; in regard the *miſpickel* or *arſenic-pyrites*, that is, the white *pyrites*, by the ancients called *pyrites argentei coloris*, comes properly under that diſtinction, tho' uſually holding the leaſt ſilver, in compariſon of the yellowiſh and yellow: and tho' almoſt all *pyrites* hold ſome ſilver, yet it may be queried, whether it does ſo as a *pyrites*, without the intermixture of any other foreign vein. The mine-

ſecre-

ſecretary, Mr. Lichtwer, a perſon extremely well ſkilled in the buſineſs of minerals, ſhewed me ſometime ago at Dreſden a ſteely cloſe *pyrites-die* from Norway, from which there iſſued a pretty large thread of native ſilver: But this ſilver we muſt not conſider as growing out of the body of the *pyrites*, but as ſomething exiſting previous to, and encompaſſed by the *pyrites*, and which probably might have had its root or origin in a *quartz* or *ſpad*, as ſuch a body actually adhered to it, and in ſuch, native ſilver often lodges; having myſelf had from Norway a *quartzy* or flinty ſample, cloſely intermixed with foils of ſilver, under the title of a *ſilver-pyrites*, tho' nothing of a *pyrites* was obſervable thereon.

From the other contents of the *pyrites* have ariſen the appellations of *ſulphur*, *vitriol*, *arſenic* and *ſandarach pyrites*, and accordingly *pyritæ* have in ſome meaſure been ſorted; in particular, ſulphur and vitriol *pyrites* is a diſtinction without a foundation; ſeeing all *pyritæ*, containing ſulphur, yield vitriol too; and all yielding vitriol, muſt needs have held ſulphur: but it is proper to obſerve, that they muſt be firſt worked for their ſulphur, then for their vitriol; and that *pyrites* once worked for vitriol, irretrievably loſes its ſulphur. So that this diviſion of *pyrites* has only ſerved to introduce error and miſconception into the ſubject; as if theſe were quite diſtinct ſpecies of *pyrites*, and that ſome *pyrites* held vitriol formally, and in their native compoſition, in manner as moſt of them do ſulphur. Tho' this is not to be taken ſtrictly neither, as there are ſome attending circumſtances to juſtify ſuch a diviſion, for the ſake of illuſtration, tho' not of neceſſity: for inſtance, at Geyer in Meiſnia there are chiefly two ſorts of *pyrites*; the one of *Catherin-mine* at Johan-Georgen-Stadt; the other, of the *pyrites groove* of

Geyer itſelf: from both which ſulphur may be driven or procured; yet it is actually worked from the firſt ſort only; as the other, on account of its greater impurity, and conſequently large *heap-work*, and the tedioufneſs of working it, would not compenſate the trouble. On the contrary, there is vitriol procured from both ſorts: from the firſt, as the ſulphur and vitriol are almoſt at once worked for, or the advantages of working the ſulphur exceed the vitriol expences: from the ſecond ſort, as the expences of deſulphuration, wherein the proper furnaces, and veſſels, and attendance come high, are ſuperſeded, and the ore only prepared by a courſe of common *roaſting*. Now as that ſort from the *pyrites-groove*, on account of its foreign admixture, which is chiefly an iron-ſtone, is not worked for ſulphur, it may with ſome propriety be called a vitriol, and not a ſulphur *pyrites*, and may in ſome meaſure be oppoſed to the other: might not therefore the perſons, who firſt applied theſe names, have a regard to the ſpontaneous vitrioliſation of that ſort, and imagine them to have vitriol only, and no ſulphur? Now, from my own ſmall experience in thoſe matters, I look upon all *pyritæ* containing ſulphur, ſpontaneouſly to reſolve to a vitriol, tho' many ſlowly and with difficulty; the feweſt, with diſpatch and eaſe. Yet it might be allowed, to call thoſe that inſtantaneouſly vitrioliſe in their entire ſubſtance, without any refuſe, out of eminence *vitriol-pyrites*; as the Heſſian *iron-earth*, for inſtance, called alſo *Magneſia vitriolata*; and in general, the *pyrites* conſiſting of iron and ſulphur, without any other admixture, and of a round figure.

The diviſion into ſulphur and arſenic *pyritæ* is better grounded. Of the firſt ſort are all thoſe at the mines and ſmelting-huts, called ſimply *pyrites*, and employed for procuring that regulus, called *crude-ſtone*, ſulphur, &c. Again, all *copper-*

pyrites

pyrites and copper-ores, which tho' with us not work'd for, yet contain ſulphur. Tho' *arſenic-pyrites*, in its metallic contents, eſpecially iron, coincides with the other, yet in its volatile part it differs greatly. And tho' ſulphur and arſenic are often found together in *pyrites*, yet there are ſome without any arſenic at all; and again, not a few that contain no ſulphur, but only a pure arſenic. Further, tho' ſulphur and arſenic readily unite, yet are they never produced the one from the other. So that this diviſion, in preference to the others, particularly the foregoing, may be permitted as taken not ſo much from the different matters for which this ſort is worked, as from their different principles, and ſeems to have ſome foundation in nature. At Friberg tho' we uſe not the term *arſenic-pyrites*, yet we denote the ſame thing by *miſſpickel* or *white-pyrites*. 'Tis here to be obſerved, that the black *arſenic-pyrites* or *fly-ſtone*, is not properly of this claſs, as being entirely fugitive, without leaving any fixed earth behind, and conſequently having one part only of the eſſence, and not the other fixed, metallic principle of a *pyrites*.

The appellation *ſandarach-pyrites*, has introduced numerous miſtakes: ſandarach is only a ſulphurated arſenic, or an arſenic tinged yellow with ſulphur, not having its own peculiar *pyrites*, contradiſtinguiſhed from the *arſenic-pyrites*, as one might be led to imagine: ſeeing it conſiſts of the very ſame parts peculiar to the *pyrites* itſelf; only that theſe are ſeldom lodged together in a due proportion, to fit them to be worked for ſandarach, without making ſome additions. In moſt *ſulphur-pyrites* there is at laſt procured a ſmall quantity of ſandarach (as moſt of them hold ſome arſenic) and but a little; and that either in the courſe of purifying the crude ſulphur, as is obſervable from the beautiful tranſparent, ruby-red ſublimate, and

orange-coloured powder, or from the reſidue or *ſulphur-ſlags*, as they are called, with or without further treatment; or alſo in the roaſting-huts, which generally appear done over with a red ſort of glazing. Some *pyritæ* yield more of it, but ſtill in the proportion to their ſulphur and arſenic. Tho' to ſpeak with propriety, it would be a difficult matter to find a *pyrites*, ſo mixed by nature, as without large additions to yield much ſandarach, and not either moſtly a ſulphur, or a pure ſooty arſenic; for, to compoſe a ſandarach, the arſenic muſt predominate or exceed the ſulphur by about 3 or 4 parts; and a *pyrites* of ſuch a mixtion is very rare, and what I never myſelf obſerved; but rather, that where the *pyrites* greatly partakes of arſenic, the ſulphur is deficient; and where, on the contrary, the ſulphur is in a ſufficient, not to ſay, a large quantity, there the arſenic is not ſo. The *miſpickel*, or *white pyrites*, is therefore for the moſt part purpoſely mixed, either with ſulphur-ſlags orwith *ſulphur pyrites*, as ſhall be ſhewn hereafter. 'Tis true, the *white-pyrites* might be, nay, by ſome is really called a *ſandarach-pyrites*, and 'tis poſſible there may be *pyritæ* having ſuch a proportion of ſulphur and arſenic, as to yield ſandarach without uſing any additions.

But the uſual way of procuring a ſandarach is to employ two ſorts of *pyrites*, the white and the yellow, or to uſe, as additions, *ſulphur-ſlags*; whence it appears, that ſandarach is not a conſtituent principle of *pyrites*, but that it conſiſts of two parts thereof, namely, arſenic and ſome ſulphur, really, but diſperſedly, exiſting in the *pyrites*, and run together in the courſe of the proceſs for ſandarach.

Smelters have likewiſe their *ſtone-pyrites*; to underſtand which, it is to be premiſed, that *ſtone* at the huts denotes that crude, ſemi-metallic body,

or

or that regulus, concentrated by ſmelting the coarſer ſorts of ores, and denominated either from the operation of *crude ſmelting*, or from the lead and copper, as the one or the other of theſe happens to predominate. In the operation called *crude-working*, the ſmall or poor, quartzy, rocky, mock-leady ores are, without roaſting, ſcorified, drained and concentrated, by means of the *pyrites* naturally adhering to the *mixt-work* or ore, or of what is purpoſely added, into a narrower or ſmaller compaſs or body, from their otherwiſe unſeparable and barren minerals; which body reſembles a ſtone rather than a metal. The *pyrites* here employed is commonly *ſulphur-pyrites*, in particular the coppery, nay, copper ore itſelf, if to be had. There is nothing extraordinary in this ſtone, only the name *pyrites* has been given to it by cuſtom.

If from the internal we proceed to the external conſideration of the *pyrites*, we ſhall find them of various figures and colours; as round, angular, oblong, flakey, *&c.* and white, yellow, *&c.*

The figures of *pyrites* being extremely various, the following are the principal:

I. *Pyrites idiomorphos*; which is, 1. ſpherical, or hemiſpherical; in this laſt form it is generally found radiated and lamellated; oval, cluſtered, criſtated. 2. Angular, conſiſting of four or ſix ſides; and this laſt cubical or teſſulated, oblong, rhomboidal, cellular, or honey-combed; of eight, ten, twelve, fourteen ſides, priſmatical, trapezian or irregular. 3. Bracteated or tabellated. 4. Fiſtular or piped.

II. *Pyrites ſynmorphos.* 1. Lithoxiloidical, as if fibrous, or pyritifi edwood. 2. Conchitical. 3. Cochlitical. 4. Cylindrical or Belemnitical. 5. Turbinitical, or Pyramidal. 6. Conical 7. Aſtroitical.

Theſe various figures of *pyrites* are reducible to round and angular; unleſs we except the foliated,

and thoſe that conſiſt of parallel threads or fibres; the former appearing as ſo many accumulated leaves; tho' not ſeparable into tables or plates, like ſpad or Muſcovy-glaſs; the latter, as ſo many fibres in a muſcle, or piece of wood, tho' not actually to be parted into ſuch, as having received that appearance only from the piece of wood that happened to lie near them. Nay, the ſpherical themſelves conſiſt of pure radii or cones, whoſe ends jutt out beyond the external ſpherical ſurface, and there exhibit all manner of eminences, as may be ſeen by the ſmootheſt ſort, without a magnifying glaſs; ſuch are the Heſſian, and thoſe of Toplitz and Altſattel. But the half-round and the kidney formed, as thoſe at Friberg called *cobald*, conſiſt not of radii running from a center to a circumference, but of ſhells or coats, that lie upon each other; or whoſe radii run parallel, and to different points, conſequently forming no genuine ſphere. Of the angular, the four ſided is the rarer ſort; ſtill rarer is the pyramidal four-ſided; where a narrow ſide ſerving as a baſe, the other three equal ſides run to a point. A ſix-ſided *pyrites*, on the contrary, is more, nay, moſt common of all; with angles often ſo accurately ſquared, as if done by rule. Such I have had in particular from the Bannat of Temeſwaer and from Pretſchendorff; tho' not all ſo exactly ſquare, but that there were ſome rhomboidal, ſome quite irregular, with here and there ſides depreſſed, angles often broken off.

In general, we are to obſerve of the cubical (the ſeveral ſorts of which hitherto mentioned often lie together, as at Pretſchendorff) that they chuſe beds, where there are none of eight or more ſides. The ſix-ſided cellular or honey-combed ſort is remarkable in this, that the cells are ſo adaptedly filled with pieces of *Glitter*, as to ſhew like a ſet

of

of looſe teeth, accurately fitting the ſides, as if ſet with the greateſt care.

The round *pyrites*, as was before obſerved, is either ſpherical or hemi-ſpherical The ſpherical, or whole round, have in the middle a point, from which ſhoot radii to the circumference, where theſe radii always project, either in ſmooth bodies, or in ſharp points, often undiſtinguiſhable; and again, often ſtriking the eye. The hemi-ſpherical, which are thoſe arched, or bulging on one ſide only, are partly radiated, partly coated; both commonly conſiſting of an impure, namely, an arſenical ſulphur, and being alſo ſomewhat coppery; whereas the whole-round are generally without either arſenic or copper, and therefore yield the pureſt ſulphur and iron-vitriol. Beſides theſe there is alſo a broadiſh, oval, round ſort, uſually called *pyrites-kidnies*; alſo a *botrytes*, or cluſtered ſort, conſiſting, as it were, of pure, ſmall globules (whither alſo are referable the criſtated ſort) and ſuch configurations we often meet with in the *blood-ſtone*, or *glaſs-head*: the cylindrical ſort are caſt in the ſhell of that ſea-fiſh, from which the *belemnites* takes its figure, The cone-round, the *cochlites*, &c. have ſome ſea-ſhells, in which nature has lodged and formed them, for the ground of their figure.

Scheuchzer has obſerved many of theſe round *pyrites* in Switzerland, waſhed down by rains and water-floods from the heights of the Alps, and ſuppoſed to be *lapides fulminares*, thunder-ſtones; not ſmooth, but unequal and rough; of a ruſty caſt, appearing radiated upon breaking, and glittering of the colour of gold and ſilver*. But he ſhould have told us whether it was on account of their contents, or their colour, that he calls them coppery (*pyritas æreos*) as I have not hitherto obſerved

* Iter. Alpin. I. p. 2.

ſerved a ſpherical *pyrites* that was coppery. In the iſland Staritzo, a like ſort, of the ſize of oranges and lemons†, is found.

To illuſtrate the figures of the *pyrites*, in varying which nature takes a peculiar pleaſure, it may be proper to conſider thoſe of other ores. Gold-ore, as ſuch, is a rare thing, conſequently it is difficult to aſcertain any peculiar figure of it; the gold that is found in certain ſands, clays, and other earths, in flints and ſtones, being rather in a native than ore ſtate, as in ſpangles, foils, and grains. Silver-ores, as the *glaſſy* and *red-goldiſh* ſort, have their peculiar figures; though the latter more than the former, frequently exhibiting ten or twelve ſides, but they are oftenеſt found priſmatical, like long angular ſtaves or bars, yet of unequal ſides, and like mountain-cryſtal, terminating in four or five unequal-ſhaped ends. 'Tis remarkable of *glaſſy ore*, that it is generally found of a cubical form, and regular enough; a circumſtance never to be affirmed either of *red-goldiſh*, or any other ore, if you except *lead-glitter* or *galena*, and a kind of Swediſh iron-ſtone of the nature of *glitter*. The white goldiſh ore may be deemed a copper, rather than a ſilver ore; and ſo indeed may the other two, from their yielding large quantities of copper. Iron-ore, or, as it is called, *iron-ſtone* (to diſtinguiſh it from *iron-pyrites*) generally conſiſts in ſhoads or fragments, in *ſquats* or flat veins, exhibiting no peculiar figure, if we except that called the *glaſs-head*, or *blood-ſtone*, diſtinguiſhable partly by its ſpherical, partly by its hemiſpherical figure, and its brown-red, or ruſſet hue, and thence denominated *botrites* blood-ſtone. Now as no other metal beſides iron, is, in its ore-ſtate, of a round figure, except that of *iron-pyrites*,

† Straufii itinerarium, p. 97. Confer. G. Agricol. in fol. p. 658.

tes, this circumſtance cannot be deemed entirely accidental, but as what deſerves our cloſeſt attention. Lead-ore, eſpecially the ſort called *glitter*, (*galena*) is always ſix-ſided, partly cubical, partly oblong, and never obſerved of any other figure. That peculiarly rare lead-ore, which being commonly whitiſh, greyiſh, and greeniſh, holds no ſilver, not unknown at Tſchopau, nor formerly here at the Tſcherper, is always priſmatical, and oftentimes flaky, like a *ſpad*. Tin-ore principally manifeſts itſelf in tin-ſtone, alſo in ſome granates. The former are moſtly regular bodies enough, from ten to twelve ſides; the latter are never regular, but with unequal angles and ſides; ſome of them are pretty flat on their ſurface, and with angles only cut a little, or often quite away, and this either quite flat, or ſoon running into ſharp points. Quickſilver-ore, which is principally cinnabar, has, beſides its uncommon red colour, no native, peculiar figure; though quickſilver be in itſelf, by means of art, transformable into a thouſand ſhapes: the reaſon may be, our not being always able to diſtinguiſh it in ores, or to ſtrip it of its maſk; to me it ſeems very probable to lie concealed in arſenic, and the like volatile, metallic bodies. Antimony-ore greatly reſembles cinnabar, like it conſiſting of *ſpicula* or needles; with this difference, that in the latter the *ſpicula* always run parallel, but in the former they often appear like radii converging to a centre. Hither alſo are referable, with reſpect to their configuration, the beautifully red, ſteely-cloſe *cobald-bloom*; the red antimony-ore; the iron-coloured, radiated *wolfram* of Altenberg in Miſnia; alſo another ruſſet ſort from the ſame place, which is highly arſenical, and laſtly, ſeveral biſmuth-ores; ſeeing ſuch diſtinctly manifeſt a radiated texture.

Precious

Precious ſtones may, with reſpect to their various figures, be ſuppoſed to approach ſomewhat nearer to the *pyrites*. The mountain-cryſtal, that is, the diamond white tranſparent ſort, as ſurpriſing as it is common in our mines, aſſumes all manner of figures; tho' the more common be either the cubical, or the priſmatical figure; this laſt running to a point with five unequal ſides and angles. Topazes, hyacinths, emeralds, ſapphires, and the like variegated ſtones, generally affect a cubical form: Tho' indeed the granate uſually is ſeen to have twelve and fourteen ſides (a thing not common for the other precious ſtones) and never to be priſmatical. 'Tis however to be added, that the granate (whether all I know not) is ſomething more than a ſtone ſlightly tinged; it is rather richly ſaturated with ſome metal, particularly tin, whether with gold is not ſo evident; ſo that it may juſtly claim rank amongſt genuine tin-ores. Of the priſmatical figure, we find at Stolpen in Miſnia a hard iron-coloured, black-grey marble, called *Baſaltes* (*a*) touch-ſtone; of ſeven, ſix, five, and ſometimes only four ſides, and of ſuch length and thickneſs as to be ſet up on end in the corners of ſtreets and near houſes. Of the like figure are the ſtones near the draining-hut of Grunenthal, in the road from Brandau to Gerkau. Of a triangular figure are the *quartz*, or flint of Anholt, an Iſland near Jutland; of which the learned in Denmark make mention, but which I never ſaw, any more than other ſtones of that figure (*b*). Laſtly, with regard

(*a*) Baſaltes derives either from Βασανίζω, I explore or try; or from Biſaltia, a country of Macedonia; and then 'tis the ſame as Biſaltes. Geſner, p. 21.

(*b*) Inſula hæc, inquit Olaus Borrichius, in ſinu Codano infinitos habet ſilices nigros, albos, varios, in ſabulo hinc inde ſepultos, at ſex tranſverſos digitos in longitudinem protenſos, latos digitum unum, omnes triquetros, ac ſi manu artificis fuiſſent

gard to copper-ores, I have, from manifold experience and obſervation, made this remark, that ſuch *pyritæ* as yield no copper, are always round; thoſe that contain only a little, of eight ſides at leaſt, and thoſe that are richly ſtored with copper, commonly exhibiting ten, twelve, and more ſides.

In a word, ſo far as my experience in ores and ſtones reaches, no one ſort exhibits a greater variety of figures than the *pyrites:* and whatever figure nature gives any particular ſpecies of bodies, ſuch it continues to have unchanged, nature ſeldom or ever ſwerving from the rule ſhe has once laid down to herſelf, in any particular ſpecies. For inſtance, a *copper-pyrites* is never round, a pure *iron-pyrites* never angular, leaſt of all polygonal; a *glaſs-head* never like a *glitter*; a tin-ſtone never regular, &c. The reaſons for which muſt be neceſſary, not accidental, and well deſerving our careful attention and obſervation; for the ſtructure and configuration of minerals may be conſidered as ſo many peculiar marks and *criteria*, from whence a better judgment may be formed of their nature, and conſequently a more diſtinct deſcription and hiſtory of them be attainable, at leaſt as to their external appearances.

That diviſion and diſtinction of *pyritæ* taken from their colour is a capital one; then I reduce them to three ſorts, viz. white, yellowiſh, and yellow.

In conſidering the colours of mineral bodies in general, we are to obſerve that ores are metal impregnated with ſulphur, or arſenic, or both: and this is ſufficient to conſtitute the form or eſſence of an ore,

fuiſſent accuminati; & lateribus plerumque in illam faciem excavatis, ut Joſuæ ſervire potuerint cultris ſaxeis filiorum Iſrael circumciſionem imperanti. Act. Haffnienſ. T. IV. p. 177.

ore, whatever other accompanying parts there may be in it. Sulphur is obſerved to reduce the white metals, and the ſemimetals, as ſilver, lead, regulus of antimony, to black, or black-grey bodies; namely, to a *glaſſy ore*, a *lead-glitter* and an antimony; with mercury alone changing to a beautiful red. The red metals, as iron and copper, it turns to a yellowiſh and yellow maſs, which is our *pyrites*. Arſenic leaves white what naturally is ſo, and blanches or whitens what is not ſo. Tin it exhibits in its native white character, as appears from the tin-ſtone. Iron it brightens, as we obſerve in *Miſpickel*, whoſe native earth is an iron. Copper, tho' naturally red, it thoroughly tinges with its own livery, as ſufficiently appears from highly arſenical copper-ores. Silver it changes red, a remarkable inſtance of which we have in the *red-goldiſh* ores. For producing the yellow, brown and black caſts in ſome tin-ſtones, ſome ſulphur muſt accompany the arſenic, to account for an appearance ſo oppoſite to that of tin and arſenic. To avoid prolixity, I ſhall only hint, that arſenic and ſilver, ſulphur and quickſilver, alſo ſulphur and arſenic, do together exhibit colours extraordinary red. In *lead-glitter*, *glaſſy ore*, antimony, and *red-goldiſh* ore, the proximate cauſe of their colours lies in none of the parts whereof theſe bodies conſiſt, but is firſt produced by an intimate action and reaction of theſe parts among themſelves. In the others, and in many genuine ores, we obſerve the parts introduced bringing along with them their proper colour; particularly in the *pyrites*, where the ſulphur loſes not its yellow character; and the *iron-pyrites* turning only a little pale from the greyneſs of the iron; in *copper-pyrites*, on the contrary, the colour being heightened, from the common experiment of a red always heightening a yellow: arſenic is the manifeſt

niteſt cauſe of the whiteneſs of the *miſpickel*, or *arſenic-pyrites*; alſo of certain copper-ores, in which it exceeds the ſulphur in quantity.

The three above mentioned capital colours of the *pyrites* are to be taken in a comparative, not a ſeparate view: for, the *ſulphur-pyrites* being viewed apart, ſhews white or grey; but placed near the *miſpickel*, its yellow caſt ſhews to greater advantage: in like manner the yellow ceaſes to be diſtinguiſhable, unleſs compared with the yellowiſh. The reaſon is, that theſe are three not very oppoſite colours, but eaſily running into each other, without deſtroying, tho' lowering or heightening, one the other: again, they ſtand in ſuch a degree of mutual affinity, that many others different cannot be placed between them. Theſe colours are to be underſtood as entirely penetrating into the ſubſtance and body of the *pyrites*; conſequently they are not owing to the adjoining mineral, which indeed often ſtrikes the eye in ſuch a manner, that the *pyrites*, eſpecially if lying interſperſed therein, cannot well exhibit its natural colour; ſome caution alſo is neceſſary to prevent being deceived by the variegated, the red and green, the gold-yellow, the blue, &c. colours, which ſometimes ſettle upon, without penetrating into the fibres or ſtrings of the veins, and are uſually called *copper-blooms:* to which muſt be added, that *pyritæ* being long expoſed in the weather, change their external colour; whence it is poſſible to be miſled by that powdery coloured ſubſtance, which is either ochre or verdigreaſe, ariſing in part from the deſtruction of the *pyrites*, and lying externally upon it, without making a part of its eſſence or compoſition.

This diviſion taken from the colour will, upon trial, be found not only eaſy and diſtinct, but comprehenſive of all the variety of the *pyritæ*. There may,

may, 'tis true, be ſamples, not perfectly coming up to any of the abovementioned three colours; one yellow may happen to be higher than another, nay, needs muſt, as not agreeing in their contents, namely copper, to which the yellowneſs is moſtly owing. The ſame holds of the yellowiſh, wherein often there is no arſenic at all, often very little, and often a great deal; now the arſenic lowering or bringing down the yellow, 'tis not poſſible to fix this colour to an indiviſible point. The white alone is the moſt conſtant colour, as being owing to the arſenic; having obſerved that where it is lodged in the proportion, it bears in the *arſenic-pyrites*, not only the ſulphur, which might ſomewhat alter the colour, muſt be entirely excluded, but the copper alſo. But theſe differences in colour are ſo very minute, as ſcarcely to be diſtinguiſhable; the three, that have been aſſigned, being to many difficult enough to diſcern with exactneſs.

The white *pyrites* is in eſſence or nature only the *poiſon-pyrites*, the *arſenic-pyrites*, the *miſpickel* and *miſpilt* of Friberg, and in external appearance not eaſily diſtinguiſhable from the *white-goldiſh* ore, the *ſmalt-cobald*, eſpecially the latter, though darker, internally differing much among themſelves. The genuine ſmalt-cobald agrees, 'tis true, in its volatile portion, namely, the arſenic, with the *arſenic-pyrites*, but in its fixed portion widely differs; ſeeing the true cobald ſmelts to a beautiful blue glaſs, which the *arſenic-pyrites*, on the ſcore of its iron refuſes. Cobalds are of two principal ſorts. 1. That yielding the fineſt ſmalt, and appearing of the darkeſt grey, ſo as to be eaſily diſtinguiſhable among the *miſpickels*. 2. A ſort ſomewhat brighter, found alſo among the other, in luſtre almoſt vying with the *arſenic-pyrites*, only a ſmall matter darker than it; and yielding by far not

not ſo beautiful a ſmalt or blue colour, as the other.

The *white goldiſh* ore, to which may alſo be refered the *white ore*, the *fallow ore*, and the *fallow-copper-ore*, in colour almoſt reſembles the fine cobald, only ſmoother and thus more gliſtering, and with the greateſt difficulty diſtinguiſhable from the *white-pyrites*. The *white* ore, which at the Halſebruke is uſually called a rich copper ore, tho' far ſhort of the *white-goldiſh* in goodneſs, is only a *fallow-ore*. Fallow-ore, which is a grey ſilvery copper ore, and *fallow copper-ore*, which is a copper-ore poorer in ſilver and richer in copper, are generally darker than the *white-goldiſh* ore, the *fallow copper-ore* being the darkeſt of all, whence it is eaſily known from the white *pyrites*, provided you can rightly diſtinguiſh it from the cobald, particularly the ſecond ſort, and from the white-goldiſh ore. There is a kind of antimony-ore from Schlaitz in the Voigtland, often ſo little radiated, as ſcarcely to be eſteemed an ore of that kind, yet of ſo dark a grey, as never to be confounded with the white *pyrites*, the *white-goldiſh*, the *cobald* and the fallow ore. To range the ores, hitherto mentioned, by the ſeveral degrees of their lighter and darker caſts, and to begin with the lighteſt, they ſtand thus: Firſt, the white *pyrites*, then the cobald of the ſecond ſort, next the fine *cobald*, then the *white-goldiſh* ore, the *white-ore*, the *fallow-ore*, and *fallow copper ore*. A perſon, not carefully comparing together and accurately examining theſe ores, may eaſily miſtake, but a perſon of experience can directly upon ſight diſtinguiſh, without the trouble of comparing them; and yet there are real differences, which may afford ſufficient direction to a learner to make a diſtinction between ſuch ores. At leaſt the *arſenic-pyrites* does, in regard to the yellowiſh, or *ſulphur-pyrites*, and

to the yellow, or *copper-pyrites*, rightly claim the title of *white-pyrites*; as compared with theſe it certainly ſhews white.

The yellowiſh and yellow *pyrites* are not near ſo hard to diſtinguiſh as the white. The former is a ſort conſiſting of ſulphur and iron, and having little or no arſenic or copper, and in different views, now called *ſulphur-pyrites*, again *iron-pyrites*, and at Friberg ſimply *pyrites*. It manifeſts a middle colour between the true *copper-pyrites*, or the *pyrites-copper ore* and the white *pyrites*; which colour can neither be called a white nor a yellow, but a yellowiſh, and diſcoverable upon comparing the white and the yellow therewith; as in regard to the white alone it muſt be deemed to be actually yellow, and in regard to the yellow alone, actually white; obſerving to learn to diſtinguiſh it from the dark vein-ſtone, the dark ores and minerals in mines, as mock-lead, glitter, &c. where its yellowneſs cannot ſtrike the eye; and to guard againſt being impoſed upon by the external, often gold-colour, which is only ſuperficial; remember to break the ſample, and judge of it as it ſhall then ſhew internally coloured.

The yellow *pyrites* may be eaſily diſtinguiſhed; its peculiar characteriſtics are the copper and ſulphur it holds: its yellow nearly coincides with a *ſiſkin-green*, which might induce one to call it a green *pyrites* rather. But as in the colour, called ſiſkin-green the yellow is the ground-colour, a little green only ſerving as a heightening; and as the ſecond or middle ſort of *pyrites* muſt have been called a yellow and not a yellowiſh, which the eye oppoſes; and then as the adjunct, green, might not have been ſo expreſſive, but apt to miſlead to the miſtaking it for a very different ore and mineral, done over with a copper-green or verde-greaſe; theſe are ſufficient grounds for acquieſcing

in

in the abovementioned diſtinction of colours. At leaſt the appellations, yellowiſh and yellow, are ſufficiently expreſſive, to cauſe no miſtake in the application of them. And provided we know how to diſtinguiſh the white *pyrites* from the abovementioned white or white grey ores, particularly the cobalds, which cauſe the greateſt difficulty; there will be none at all, upon ſight of the yellowiſh and yellow, or braſs colours in ores, ſecurely to pronounce ſuch bodies real *pyrites*; as there are neither yellowiſh nor yellow ores, that are other than *pyrites*, conſiſting of ſulphur, iron and copper.

In ſome authors we find the appellation *wild* applied to *pyrites*. *Wild*, is a term much uſed in mineralogy and applied to waters, ores, rock and ſtone. *Wild waters* are ſuch, as weaken or ſpoil a brine or a mineral water. A *wild ſtone* or *rock*, what neither holds any ore or metal at all, or not the metal we look for. In like manner may the *pyrites* be called *wild*, when not anſwering our purpoſe, either for gold, ſilver or copper; as a gem may be properly called *wild*, which fails either in colour, purity or firmneſs; * is ſoft, pale, dirty, plumoſe and clouded.

To the *ſtone-pyrites*, procured from the operation of crude-ſmelting, and containing pure ſulphur and iron, is uſually oppoſed the *ſpeiſe-pyrites*, an arſenical, ſemimetallic regulus, properly called *ſpeiſe* and procured from arſenical *pyrites*.

The abovementioned diviſions of the *pyrites*, taken from their nature, figure, colour, &c. have, as was ſaid, their peculiar reaſons, and may prove of uſe in natural hiſtory; not only for underſtanding the old writers, but the different methods of

* Roſsler's Bergbau ſpiegel. p. 114, and 151. 7.

treating the *pyrites* itſelf; the ore-ſmelter having his *ſtone-pyrites*; the ſulphur-maſter, his *ſulphur-pyrites*; the vitriol-boiler, his *vitriol-pyrites*, &c. tho' they all mean one and the ſame thing: for the *ſulphur-pyritæ* both yield a good *crude ſtone*, and are alſo proper for making vitriol.

The appellations, borrowed from the iron and copper, diſtinguiſh the metallic contents, and conſequently the grand principles of their reſpective minerals; but may be apt to miſlead, as implying iron not to be the ground-earth of all the *pyrites*; and excluding the other principles, viz. the ſulphur and arſenic, which are quite loſt in theſe appellations. The external figures do certainly denote ſomething peculiar, which the colour may not: for from my own experience of various *pyritæ*, I may boldly affirm a ſpherical ſort always to contain pure iron and ſulphur without any the leaſt copper or arſenic; yet hence it follows not, that the angular *pyritæ* always hold copper, ſeeing they partake of iron equally with the round; nor can we always diſtinguiſh whether a ſample under examination be a part of a round or a half-round *pyrites*, which laſt holds copper conſiderably, or at leaſt is not unmixed with arſenical parts. Conſequently, ſo far as I have hitherto conſidered the matter, I find myſelf obliged to drop the figures and adhere to the colours, as affording the moſt proper diviſion of the *pyrites*, and better denoting their internal properties, which the figures rarely do; the white *pyritæ* undoubtedly containing arſenic, the yellowiſh, ſulphur, the yellow, copper. And a perſon much converſant in ores, will, upon ſight, be capable to pronounce, whether the former conſiſt of pure iron, or, of copper too, and the proportion of each; the buſineſs in this caſe reſting on the various degrees of one and the ſame colour, not to be deſcribed by words, but learned by a repeat-

repeated inſpection and compariſon of ſamples. The following circumſtances however may help our obſervations thereon; the more the yellow inclines to a ſiſkin-green, the more dead and leſs gliſtering it is, and the cloſer more clear-grained and firm the ſample, richer the *pyrites* proves in copper.

It has been already remarked that the whiteneſs of the *pyrites* is a ſign of its arſenic, and I might add of its iron too, but that there is a ſingle, yet rare, inſtance ſtanding as an exception: at Chemnitz or Stolberg in Miſnia, there is a whitiſh *pyrites-copper-ore*, holding at the rate of £ 40 the quintal, plainly diſtinguiſhable from *miſspickel*, in its pale colour, compactneſs and firmneſs, tho' in a manner not to be deſcribed; however as its whiteneſs is owing to its arſenic, it ſtill remains a general propoſition, that arſenic imparts that colour; tho' it be difficult to diſtinguiſh the whiteneſs faſtened on the copper in this uncommon inſtance, from that on iron in the *miſspickel*.

CHAP. IV.

Of the BEDS of the PYRITES.

THE yellowiſh or *ſulphur pyrites* is met with in all manner of ſtone: 1. in *quartz* or flint it readily lodges; this very cloſe, firm ſtone generally affording beds, and directing to ores, that when once diſcovered, the Miner imagines himſelf to be, if not in the actual poſſeſſion, yet in the tolerably certain hope of meeting with an ore; it alſo forms the *ſelvages** of Veins, and encompaſſes the *pyrites* as ſo many ſhells or coats. The *pyrites* often adheres externally to *quartz*, as if run or melted upon it, or ſticks like grains or buttons, or like ſand ſtrewed on it; as is particularly obſervable in the beautiful colours of the *copper-pyrites*.

2. In Marbles, called in the language of Miners, *horn-ſtone*, and reſembling *quartz*; except that the former are generally white, ſeamy, veiny and flakey; the latter for the moſt part coloured, as brown, yellow, red, grey, black, *&c.* and moreover are not ſo remarkably veiny, but cloſer and conſequently fitter to work. I have more eſpecially obſerved the *pyrites* on red and yellow jaſper, chalcedon, and the like, which are not unduly claſſed amongſt marbles.

3. In

* A vein has its bed and cover of rock, both which are parted or diſcontinued on the ſides of a vein, and theſe ſides covered with quartz, or with a finer kind of mold; and this is what Miners call the *ſelvages*.

3. In *ſpad* which is directly oppoſite to *quartz*, being a flakey, crumbley, ſhivery, calcarious ſtone, more frequently entirely white, but ſometimes of a brown-red or ruſſet, as well as of other colours, and ſofter than *quartz*; ſo as to bear being ſhaved with a knife, nay often with the finger-nails; whereas *quartz* often approaches to a diamond in hardneſs; tho' *ſpad* be heavier than *quartz*, to a degree of giving a ſtrong ſuſpicion of its holding a metallic body, little or no metal hath hitherto been procured from it; this ſpecies of ſtone having conceived more of the mercurial, metallic earth than of the quartzy, glaſſy, firſt earth of Becher; now in and upon this *ſpad* the *pyrites* as readily fixes, as it is common in our mines. I have had ſeveral inſtances of *pyrites* in tinny vein-ſtone, where Muſcovy-glaſs, a ſpecies of *ſpad*, uſually *breaks*.

4. The *pyrites* lodges alſo in lime-ſtone, gypſum, alabaſter, *&c.* Not *vein-wiſe*, but rather *neſt-wiſe*, and *kidney-wiſe*, unleſs where other veins, carrying along with them *pyrites*, happen to traverſe; as appears from the calcarious *ſhoad* of the Schloſsberg near Toplitz.

5. *Shiver* not only holds *copper-pyrites*, or *copper pyrites-ore*, as being what is common to it, but alſo *iron pyrites*; there having been ſent me a ſample in particular from the Shiver-quarry near Goſlar, where it forms a genuine flat-layer or ſquat.

6. *Pyites* lodges alſo in ſtone-coals, a thing not to be wondred at from their great affinity, as both have ſulphur in common, which abundantly appears from the ſtone-coal works at Peſterwitz near Dreſden.

7. In ſand-ſtone, of which thoſe brown-red, ochry, iron-ruſt neſts obſervable in ſtone quarries are ſufficient evidence: and in particular at Burg-

thanne in the territory of Anſpach we find a dark, ochre brown ſtone, concreted of ſand, or a ſand-ſtone and *pyrites* particles of the ſize of hemp ſeed, ſome ſmaller, ſome bigger, of eight ſides.

8. Of *pyrites* in lime-ſtone we have inconteſtable evidence from the famous lime-ſtone quarry of Querfurt, from the Schloſsberg of Toplitz, and in particular from the Beyerberg in the territory of Anſpach, immediately beneath the under-turf earth.

9. In loams and clay pits *pyrites* is often met with; the Heſſian iron earth ſhews this: and the Pretzſchendorff *pyrites* lies towards the *day-ſquats* in a fatty, *talcky* vein-ſtone.

10. We find *pyrites* in a kind of marly ſtone, a fatty, clear ſort of ſtone-earth, commencing a ſtone, yet not ceaſing to be an earth; as may be ſeen at Toplitz, and from a large quarry at Cottitz in Bohemia. *Pyrites* lodges alſo in *gemſs*, a ſoft, flakey ſtone, lying between the inner, hard rock and the outer garden mould.

11. *Pyrites* we find in that rocky vein-ſtone ſtriking out to the *day*, called by miners *knauer*, and to be denominated a wild, barren, dead ſtone, from its not yielding any metal.

12. *Pyrites* uſually manifeſts itſelf in and near all the wrecks or remains of the Deluge, but oftener in the fragments of minerals than vegetables; and in what are called the muſſel, periwinkle and horn Works; as the country about the Wirtemberg Bath at Boll plainly ſhews in a vaſt variety of ſamples. And Dr. Balthaſar Erhard of Memmingen has furniſhed me with Samples of *cornua ammonis*, *pectinites*, *cochlites*, *conchites*, *belemnites*, *lapides judaici*, *&c.* either filled or over-laid with *pyrites*. And indeed it is found not only in and upon petrified pieces, but on ſuch as have remained unchanged, only become

ſome-

ſomewhat calcarious, tho' ſtill retaining the nature of their proper kingdom. I have procured from M. Roſinus of Munden a piece of *pyrites*, that manifeſtly ſhewed it to have been wood, not only by its texture and growth, but actually having ſome of its original adhering to it; tho' a muſſel or other ſhell is by its nature better adapted for the conception of *ore-weatherings* or damps, even in its unchanged form: and Liſter (*a*) mentions a *pyrites ligneus* in Ireland, ſuppoſed to have been aſh-wood, turned to a load-ſtone of the firmneſs of marble.

So that there is ſcarce any ore or vein without the *pyrites* conſtituting either a principal, or at leaſt an incidental, if not the whole part of the compoſition. Gold-ores we have properly none in Miſnia: and as to the foreign, namely the Hungarian, I can form to myſelf no regular conception thereof: I have been ſhewn a ſample from Schemnitz, yielding ſome ſilver, but upon a narrower inſpection there appeared a variety of veins; as I have often obſerved *glaſſy* ore, *red-goldiſh* ore, *glitter*, *mocklead*, *copper pyrites*, *iron-pyrites*, *yellows*, *blacks*, *gooſe-dung* ore, *cinnabar* ore, all within the compaſs of a ſmall ſtone, weighing only a few loths (*b*) or ſome of theſe ſorts lying one on the other, and ſo intermixed as often to be ſcarce diſtinguiſhed by the eye tho' aſſiſted with glaſſes. This I have obſerved that the *copper-pyritæ* of Hungary anſwer beſt. But if I take to aſſay for the perfect metals a pure iron, and thus an entire clean *pyrites* (for the copper yield does not properly belong to the eſſence of the *pyrites*) as I have had ſuch from Schemnitz I have found the reſult to be nothing at all. But under the appellation gold-ore-

(*a*) De Fontib. Med. Angliæ. p. 23.
(*b*) A loth is half an ounce.

ore we muſt not include a corporal, native gold, which particularly in Tranſilvania we ſurpriſingly obſerve ſprouting out of, or wedged into a clean *quartz*, without the leaſt diſtinguiſhable trace of an ore or vein lying near it, as being already a native metal; whereas an ore, on the contrary, holds the metal in a quite different form, being blended with various ſulphureous, arſenical and other matters. There is a certain kind of *quartz* or flint exhibiting on its fiſſures a ruſty ſort of iron, which might be taken for a gold-ore: but 'tis to be doubted, whether this ruſty matter will, after parting the gold-ſpangles from it, yield any metallic contents: and 'tis known, that a native metal may lie in *mixt-work* in ſo light and tender a form, or by the operation of ſtamping be ſo reduced to a duſt, as that the noble metal cannot be *ſludged**, but be carried away by the ſtream, and lodge among this ferrugineous matter, which is taken for proof. And as to the eduction of gold out of *mixt-work* of more than one ſort of ore, inſeparably run into each other; the queſtion will be, whether the eduction depends on one alone, or two or more of theſe ores; or whether it holds not here, as with many minerals, nay pure earths, which of themſelves containing nothing of the noble metals, yet mixed with other ores, which alſo ſeparately give nothing or contribute but a certain proportion, prove *yieldy*, as I have with certainty experienced of chalk in particular, and other ſorts of earth. In ſuch proceſſes I know not whether I ſhould call the produce a *maturation* or a *tranſmutation*. This at leaſt

* In the operation of waſhing ores mixed with earthy rocky and other light matters, in order to the ſeparation of theſe laſt; the heavier metallic parts ſubſiding to the bottom are called *ſludge*; in High-Duth, *ſchlich*, whence our Engliſh, *ſludge*, ſeems to have been derived.

leaſt holds true, that between eduction and production there is a great deal of difference.

But in order to determine, whether *pyrites* lodge with gold ore, we muſt firſt aſcertain the proper ſorts of real gold-ore. For *glaſſy* ore, *copper* ore, and the like, which in Hungary above other ores, (for inſtance, above thoſe of our mines) are goldiſh, are properly ſilver and copper ores, their ground-ſubſtance conſiſting of ſilver and copper, and their gold being only incidental, ſeeing without diſadvantage to their principal conſtituent parts, the gold in theſe may be little or none at all. And ſhould ſuch be accounted gold-ores; 'tis well known that not only *iron-pyritæ break* on all hands of ſuch veins, and that copper-ores, which are themſelves *pyrites*, principally affect and exhibit gold, but alſo that near and upon white *pyritæ* we often find native gold.

Pyrites moſt readily lodges near ſilver ores, as the *glaſſy*, the red and white goldiſh ſorts, which may properly be called ſilver-ores; yet near theſe rich veins lodging as a copper rather than as an iron *pyrites*; and where it proves the laſt, as an arſenical or cobaldiſh, rather than an erratick *ſulphur-pyrites*, as I have obſerved from numerous ſamples. What is remarkable, I never obſerved a native ſilver, whatever pains I took to enquire about it, either on the white, the yellowiſh or yellow *pyrites*. Two ſingle ſamples only I have been ſhewn, tho' properly not referable thither; one, a *pyrites-die* or marcaſite, traverſed by a ſilver wire or rather a ſilver wire encompaſſed with a *pyrites*; the other, a piece of a *pyrites* partaking of a ſilver-ore, of the *glaſſy* ſort, from our Obergeburge. The ſilver neither lies on, nor grows out of the firſt, but muſt needs have exiſted there originally, and afterwards by means of the ſubterraneous *weather* or damps happened to be encompaſſed by the *pyrites*. The

ſecond

ſecond was far from being a pure *pyrites* being plainly enough mixed with the above ſilver-ore; which, and not the peculiar ſubſtance of the *pyrites*, was the ground, whence as from a root, the native ſilver, upon a narrower inſpection, appeared to proceed. And how can we expect to have ſilver growing from *pyrites*, when we know *pyrites*, as ſuch, to hold little ſilver, its ſilver generally amounting only to ½. ½. 1, at moſt 2 drams the quintal, and conſequently no ſilver growing out of it: And hence may be deduced theſe uſeful truths; 1. that *pyrites*, eſpecially the pure ſulphur and iron *pyrites* cannot be the mother, or producing matter of the nobler metals, as many might imagine from its univerſal ſpread; for inſtance, here in Miſnia, it always accompanies ſilver-ores, and appears neceſſary to their generation and encreaſe. 2. That in judging of veins and ore, we are not to ſuppoſe that matters accompanying, or even intangled with each other, proceed the one from the other; but we are rather to look on their ſubſtances, either produced at the ſame time, or meeting together afterwards. And if *pyritæ* have no *generative*, they can not be endued with a *conceptive* power for ſilver. *Grown* or native ſilver, ſo far as I know, and have had inſtances, is found on *quartz*, *ſpad*, *ſhiver*, *kneiſs**, *ochre*, *jaſper*, and all manner of *horne-ſtone*, on *gemſs* and *glimmer*, on common quarry ſtone and *knawer*. Among ores, chiefly on *ſmalt cobald* (to find it on *red-goldiſh*, *glaſſy*, and *white-goldiſh* ore is not uncommon) a peculiar inſtance of which we have in the *ſmalt-cobald* of Lacray in Lorrain. Fibres of ſilver are alſo ſometimes found in and upon iron-ſtone; but on *pyrites*, either white, yellowiſh, or yellow, as ſuch, never, or at leaſt it has not hitherto been heard off. There

* A black, fatty ſort of vein-ſtone or rock.

There is no inſtance of it on lead or tin ores. And the *foil-ſilver*, manifeſtly ſprinkled on the glimmery granate-ore from Norway, lies rather on the fiſſures or fibres traverſing this vein-ſtone than on the granate.

The ſame may be affirmed of native gold, and the like attention is to be uſed in judging of the gold-ſamples. Yet ſo far does gold differ from ſilver, that it is uſually to be met with on white *pyrites*; of which it may at leaſt be ſaid, that it is peculiarly fitted for the conception of gold. Again, native ſilver is chiefly lodged with arſenical ores, excepting white arſenical pyrites; native gold in cinnabar and quickſilver ores.

In the coarſe veins, as they are called at Friberg, where we chiefly look for lead and copper ores, *pyrites* more readily lodges than in ſilver ores. Nay in theſe laſt pyrites is either entirely abſent, or ſo ſparingly preſent, as that in many places, as at Schenceberg, Johan-Georgen Stadt, *&c.* the ores can hardly be worked without it, ſo indiſpenſably neceſſary an inſtrument is the *pyrites* in the ſmelting huts.

The *pyrites* proves a ſure guide to *lead* and *copper* ores, which with us are not eaſily ſeparable, ſeeing they generally lie ſo mixed together, or ſo near each other, in one and the ſame vein, that it appears almoſt impoſſible for the one to be without the other: and indeed it is no eaſy matter to find a vein in the earth, in what direction, and to what depth ſoever it runs, unaccompanied with *pyrites*. And of the coarſer veins, eſpecially genuine head-veins, it may moreover be ſaid, as thoſe of Hartz can verify, that *pyrites* is often, in company with *miſſpickel* and mocklead, to be met with, as far as levels and ſhafts have hitherto reached. And tho' as a pure *iron-pyrites*, it often loſes itſelf, yet it does not as a *copper*, nay it often is preſent in both forms, intermixed with *galena*, and frequently wound

wound up in, or joined close to it. The peculiar silver-veins rich in *glassy*, red and white *goldish* ores remarkably differ from the abovementioned coarse sort, as the *pyrites* generally keeps at a distance from these, nay is seldom found in the *selvages*. But I would not be here understood of veins, where some of the above noble ores are either interspersed in fissures, or *weathered* on *druse**, or lay sprinkled on the firm *mixt-work*; most of which will be found to consist of *galena*, copper-ore, *pyrites*, mock-lead, *misspickel*. The same remarks will hold good of other coarse veins.

I have observed the *pyrites-kidneys*, as they are called, to be of different sizes, some equal to musket-balls, granado's, and others even as large as cannon-balls, tho' oblong, and of a flatted round, rather than quite spherical; and generally give no tokens of being mixed with copper, whether examined by the eye or tried by the fire, yet there are some as those of Frankenberg of a flat-round, like the shell of a tortoise, that at times internally manifest some copper-ore, mocklead and *misspickel*, which the external appearance of such close bodies would give no suspicion of. And tho' the *pyritæ* disappear in *glitter stock-works*, as those of Hartz; nevertheless they are again found when the large stock or belly, formed here by the ore, and called *stock-work*, comes to contract again; as it doubtless must, tho' it runs, as is well known, to several small strings, difficult, if not impossible, to be traced.

From

* *Druse* in the *German* Mineralogy, denotes 1. Honey-combed ores, or such as are pierced with many holes, like honey-combs, by means of the subterraneous weather or damps. 2. The variegated crystals, filling up these holes again and called *metallic fluors*, or spars.

From the affinity in fundamental principles between *pyritæ* and iron ore or iron-ſtone, we may well ſuppoſe the former generally to lodge with the latter; as *pyrites* chiefly conſiſts of iron, being only a ſulphurated iron-ſtone; much as cinnabar is a ſulphurated quickſilver, or antimony, a ſulphurated arſenical* ſemimetal, called *regulus*: and indeed we find in iron-ſtone ſmall cubes of *iron pyrites*, as in that of Orbis in Bohemia. And here 'tis peculiarly to be remarked, that the *pyrites* includes a traverſing white limeſtone vein, which ſupplies the true *ſelvages*; circumſtances I have alſo obſerved of the *pyrites* in the ſtone-coal of Peterwitz. We alſo find therein a *copper-pyrites*, or rather a coppery *pyrites* traverſing it in veins as appears alſo from the ſame *pyrites* of Orbis. This the iron-ſmelters find to their coſt, when not ſufficiently ſeparated from the iron-ſtone; the ſulphur, tho' entirely forced out, leaves behind it in the iron an untoward quality: and by means of the copper, from which ſulphur is with difficulty ſeparated, adheres ſtill more cloſely to the iron, and taints it (as it does all metals in their degree of malleability and metallicity) rendering it brittle and ſhort. A coppery iron, indeed, does, when cold, manifeſt a ſufficient degree of toughneſs; but when hot, it eaſily ſnaps, falls to pieces, and ſolders not again, and is leaſt of all fit for making ſteel. That the *pyrites* lodges near that red ſort of iron-ſtone, called *glaſs-head* by miners, and by druggiſts, *blood-ſtone*, cannot well be doubted of, tho' I never ſaw nor read of an inſtance of that ſort.

Tin-

* Dr. Meuder in his Analyſis of Antimony ſeems to allow of no arſenic in the regulus of antimony. Our author ſpeaks according to the common opinion, viz. that the regulus of antimony is a mercury fixed by arſenical vapour.

Tin-ore, at firſt ſight, ſeems to have ſome, tho' a diſtant relation to *pyrites*, by its partaking of arſenic, whereby the tin or metal lodged therein is reduced to an ore ſtate; and in this reſpect, the white *pyrites* or the *miſspickel* is nearly allied to it. But to ſhew any ſulphur, which is the principal characteriſtic of the *pyrites*, in pure tin-ore is a very difficult matter. Notwithſtanding which, the *pyrites* does not forgoe its natural privilege of being univerſally preſent, as it every where joins itſelf to tin ore: and iron-ſtone reſembles it ſo very much, as ſcarcely to be diſtinguiſhed from it by the ſharpeſt eye; ſo that a ſeparation muſt be made by the magnet: and yet, what is remarkable, iron, which is ſo hard and ſtubborn, and alſo copper, incorporates with tin, which is ſo ſoft a metal; and thus may the *pyrites* in its metal-earth be conſidered, as eaſily combinable with tin; tho' by that means the tin be rendred ſomewhat hard, and in the language of the tin workers, *thorney*, whence the Engliſh tin, which equally with its ore, is free from iron, is ſo univerſally eſteemed.

That *pyrites* lodges with antimony-ores appears from the antimonial ſilver-groove at Braunſdorff. In which moſt of the ore, together with the interſperſed *red-goldiſh* ore, and ſome *hair*, alſo ſome *foil* ſilver, conſiſts of an arſenical *pyrites*, with a little copper ore: and the entire vein, which in many places is above a fathom *mighty*, as miners ſpeak, or thick, is throughout ſo charged with antimony, that the whole of it may properly enough be called an antimony ore. And it may here be affirmed, that tho' iron, the firſt principle of the *pyrites*, may ſuffer tin, yet by no means will it the *regulus*, which is the principal part of the antimony.

The *pyrites* is alſo preſent with the ore of quickſilver, particularly cinnabar, as in the matter of their

their ſulphur theſe have a great affinity with each other. And I have had a beautiful ſample of cinnabar-ore from Tranſilvania, where the *pyrites*, being quite of a ſteely cloſeneſs, lay within it, like a kernel in a ſhell.

It may in general be ſaid, that the *pyrites* is to be met with in as different forms and poſition as other ores are. Theſe are, 1. *vein-wiſe*; when the ore ſtretches downwards, oftner ſloping a little, ſeldom quite perpendicular; and ſtill growing wider or larger like a vein towards the heart. 2. *Squat-wiſe*, or in a horizontal poſition; that is, if not always quite level, yet hanging much and dipping a little. 3. *Neſt-wiſe* or *kidney-wiſe*; that is, as ſo many eggs or kernels in a kind of ſhell, thrown together at random; without any particular connection, either with other ores, the adjoining veins, or among themſelves. 4. In *ſtream-works*; which we may conſider as ſo many banks or beds, cauſed by the deluge; they are found ſometimes ſo very large, as to be called *ſtock-work* or bellies; tho' by their extenſion, undoubtedly belonging to the claſs of *ſquats* or flat veins. 5. In ſhoads, which are broken pieces or fragments of rock and ſtone, lying directly beneath the under-turf earth, and at times, by rains and floods, left quite naked; and with great violence, the effect of the deluge, waſhed and tore away from the veins; at length they acquire the appellation, *ſtream-work*, when much ore and rock, thus *ſhoved* or puſhed away, happens to lie together in a large compaſs. 6. And laſtly, a circumſtance not the leaſt remarkable, is, that ores are found upon *ſinter*, or drop-ſtone, in the ſides and roofs of old mines, a proof of their temporary exiſtence, and that they are not coeval with the world.

In all the above forms may the *pyrites* be found. For, 1. It breaks in genuine conſtant, ore-

veins; often entirely alone, as we have an uncommon inſtance at Pretzſchendorff; but for the moſt part it accompanies other veins, as was above obſerved; ſcarce ever without mock-lead being included in the very heart of the *pyrites-dice*, as we alſo learn from the Pretzſchendorff. The *pyritæ* ſetting or reaching as low as *levels* have hitherto been driven, or ſhafts ſunk, often appear to contain copper, but ſoon after afford only a pure iron; thus proceeding on, till by reaſon of the waters, they can no longer be traced. Of this we have ocular demonſtration from the Croner-mine at Friberg, and from the territory of the Tſcherpe and Hohenbirk, and an undeniable proof from volcano's and ſubterraneous accenſions; as their inflammable matter is probably, among other things, derived from the *pyrites*; which from ſuch mountains being unexhauſtible, muſt be diſtributed, not in a ſcanty and ſuperficial, but in a very plentiful manner at unfathomable depths: and again, the *pyritæ* extend outwards quite to the under-turf earth, or almoſt to the *day*, tho' the other accompanying minerals in the extremities, or firſt beginnings, are wont to diſappear or vaniſh: or, converſely, moſt ore-veins manifeſt themſelves from without inwards firſt of all by the *pyrites*; aſſuring the miner, from unexceptionable experience, of his being either already upon, or not far off a capital vein.

2. The *pyrites* affect a ſquat or horizontal bed, as *ſhiver-mines* ſufficiently ſhew; the *pyrites* always inclining to extend and ſtretch laterally, which is what we commonly call a *ſquat* or flat vein. Generally they are copper, very rarely iron *pyrites*, that affect this ſort of bed: and ſuch *pyrites-ſquats* are commonly without any admixture of other veins, as *mock-lead*, *miſpickel*, *glitter*, &c. which is the reaſon that the copper from Shiver-Mines

is finer, fitter for uſe, and more valuable than that from mixt vein-ſtone. Again, ſtone-coal pits give an ocular demonſtration to the ſame purpoſe; but here the *pyrites* is rather irony than coppery. *Pyrites* is alſo readily found along with lime-ſtone, as the abovementioned iron-ſtone of Orbis ſhews: and in lime-ſtone beds probably, as theſe commonly form *ſquats*; tho' I cannot affirm, I ever ſaw much *pyrites* there, as I have in *ſhiver* and ſtone-coal.

3. This mineral has been found to manifeſt itſelf *neſt-wiſe*, or *kidney-wiſe*, in proportion as the foſſils, that lie near us, have begun to be more carefully examined: and thus it appears not only in loams, lutes or clays, in marles, in marley lime-ſtone and in lime-ſtone, but with this difference alſo, that whereas in real ore-veins it is not unmixed with *mock-lead*, *miſpickel*, and conſequently arſenic and ſandarach; here on the contrary it is quite pure, with only its iron and ſulphur, ſeldom any copper.

4. In *ſhoads*, or broken fragments of veins, and conſequently,

5. In *ſtream-works*; as the *pyrites* may, equally with other *mixt-work*, be ſuppoſed to have been torn and ſhoved from their veins, and accumulated by ſtreams or floods. Nay, according to Roſler *, Druſe, Wolfram, alſo granates, and iron-corns, nay, even quickſilver itſelf, is found in ſtream-works.

6. It deſerves peculiar attention, that in old mine-works, the *pyrites* is found grown anew on *ſinter*, of which in the following chapter; a circumſtance ſerving to convince every impartial enquirer, that the *pyrites* lying on *druſe* and fiſſures, are, with reſpect to their origin, the effect of a

* Berg-bauſpiegel, p. 12.

temporary growth, and by no means a primitive work of the creation.

7, and laſtly. The *pyrites* is no ways uncommon in bodies of the other two kingdoms; ſuch as by accident, particularly floods, have chanced to light upon proper beds, and there have petrified, or changed to earth; as the periwinkles, muſcles, and other ſea-ſhells, at Boll, in the territory of Wirtemberg, fully ſhew. Tho' the inſtances of vegetable bodies are not ſo very common, yet, at a conſiderable depth (not to mention now the piece of wood reduced to *pyrites*, ſpoken of above) we meet with beds, ſhoved, or laid one over the other, of a *pyritous* alum, reſembling, both in external form, and texture, nothing more naturally than pieces of wood; nay, ſometimes entire large trees.

I would not here be underſtood as inſiſting on the abſolutely univerſal preſence of the *pyrites*; for, were that the caſe, ſmelters, in ſome places, could be at no loſs to work their poorer ſort of ores: but my meaning is, that there is ſcarce any ore ſo common as the *pyrites*; no one ſort of ore, ſtone, mineral, or earth, wherein it does not lodge; nor any mine, wherein it can well be a ſtranger; though here and there it is not found without ſome trouble and difficulty.

The reader is to be apprized, that, after the Friberg manner, mentioning *pyrites* ſimply, without any adjunct, I principally intend the yellowiſh, or, as it is there called, the *ſulphur-pyrites*. The yellow, or *copper-pyrites*, or copper-ore, is generally found in the ſame beds as the yellowiſh; but never, ſo far as my experience reaches, in ſuch round balls, or nuts; though often lying huddled together, like ſo many broken pieces or fragments. And ſhould ſome copper ſlip in among the round *iron-pyrites*, yet it is never found in ſuch quantity,

quantity, as may properly entitle it to be claſſed with the yellow *pyrites*, nor, conſequently, with the copper ores. I never had an inſtance of the yellow *pyrites* in lime-ſtone, gypſum-ſtone, alabaſter, *&c.* How the caſe ſtands with ſtone-coal, I know not. Sand-ſtone, ſo far as my experience goes, ſhould have little of it: muſcles, periwinkles, and the like ſhells, reduced to *pyrites*, never have a ſufficient quantity of copper, to entitle them to rank with the yellow *pyrites*, or copper-ores. The white *pyrites* I never miſſed, but in ſhiver, 'till a ſpecimen I once had, ſhewed it there interſperſed in grains. Having long, and in vain, looked for it in lime-ſtone, a ſample from Sweden ſhewed it alſo intermixed there: but in ſand-ſtone, ſo far as my obſervations and enquiries have gone, I never had any inſtance of it.

The *pyrites* is found alſo in water, but neither as in its proper matrix, much leſs, as ſpringing from water, as from its ſeed. The curious Dr. Daum, of Dreſden, ſent me, from the iſland Heiligland, in Holſtein, a *pyrites*, under the title of *marcaſita aurea marina*, which is ſulphureous, arſenical, and alſo ſomething coppery; and moreover, of a variety of figures. It is thrown on the ſhore by ſtrong eaſterly winds, and driven back again into the ſea, by weſterly. It was, undoubtedly, lodged in earth, or rock, and broken looſe by the waves. Dr. Major mentions ſome remarkable circumſtances about it; as, that in the fire it will emit a kind of cinnabar, or rather, a ſandarach, of the colour of cinnabar; alſo flowers, of an ultramarine colour; though this I never obſerved, nor heard of, in any other *pyrites*; nor can I imagine it ſhould yield any ſuch flowers. *Earth-blues*, of which kind are *ultramarine*, *chryſocolla*, *mountain-green*, and *Malachites*, are derived, 'tis true, from copper-ores, and thus from

pyrites; but not by means of fire, but of the *weather*, both that above and under the earth; as we may often ſee, in the greateſt perfection, in copper-ore ſlags, or *ſcoriæ*, after having lain long expoſed on heaps in the air. Further; ſuch *pyrites* is found accompanied with Belemnites, ſo that the inhabitants called it *falſe gold*; tho' I leave it a matter undetermined, how far it deſerves the title of a gold Marcaſite (*a*). The abovementioned author has with it performed all the experiments of lightning, and found the metallic globules melted from it, to cauſe in the hand the very ſame burning that real lightning does, namely, a ſmarting, yet without any ſtains, or other hurt; alſo, in falling down, to ſet blotting-paper on fire.

From what has been ſaid, it may be uſefully obſerved, that a great deal of attention is requiſite, in forming general concluſions, and axioms, even after a vaſt number of experiments have been made. It is extremely remarkable of the *copper pyrites ore*, that it is never to be met with in lime-ſtone, gypſum-ſtone, alabaſter, and the like: conſequently, that the nature of the ſtone and earth may ſerve, if not as a matrix, to contribute to, or lay the foundation for, the generation of ores, yet, at leaſt, often to impede their production. Were there no inſtance of a copper ore in ſhiver, where, notwithſtanding it is in great plenty (ſo very peculiarly fitted may the fatty, ſlimy ſhiver-earth be for the conception of copper ore) and in ſpreading *ſquats*, it could not fairly be thence concluded to be in none. So in regard alſo to lime-ſtone and ſand-ſtone, wherein it is never found, we might eaſily imagine copper-ore never was, nor now is produced *vein-wiſe*, but all of it ori-

(*a*) Majoris memoriale anatomico-miſcellaneum, obſ. 3. §. 4. 17. ſeq

originally created; as all ſuch ſtones and earths, conſiſting of ſand, of calcarious and ſlimy matters, the reliques of the flood, becoming afterwards hardened, were without copper-ore. And thus, propoſitions abſolutely general, are not eaſily to be admitted into the ſcience of nature: as we cannot well conclude, that becauſe a thing has not been hitherto ſo obſerved, it neither is, nor can be ſo. That a thing exiſts, and in ſuch and ſuch circumſtances, we may aſſuredly affirm, but that it cannot be in any other than theſe, would be indiſcretion to aſſert. And with this I might juſtly charge myſelf, ſhould I, from copper-ore not being hitherto found in lime-ſtone, thence form a general concluſion. In the mine-hiſtory we have many very curious remarks, deduced from much and long experience: for inſtance, that ſuch and ſuch circumſtances, and the appearance of ſuch and ſuch minerals, give hopes of ſome ore or other; but it might tend to great miſtakes, to form unlimited, abſolute propoſitions from ſuch remarks: for, often, the ores preſumed, either appear not at all, or very different from what was expected. From the nature of the upper-garden, or under-turf mould, we attempt to form a judgement of the ſubjacent mould, of the preſence or abſence of any ore, and of this or that particular ſort of ore; as if the lower contents were neceſſarily derived from the upper: we are, therefore, carefully to avoid being too precipitate in forming axioms and concluſions. Our buſineſs, firſt of all, is to make obſervations, proper remarks, and collect inſtances together, without pretending to deduce any conſequences: for how ſuperficial often are even the moſt accurate remarks and obſervations! Our experience is chance-work; our ardent purſuit after riches ſo much engroſſes our thoughts, as to make that our only end in the

buſineſs of mining: and who is the perſon, that will give himſelf the trouble of carefully examining what even chance throws in his way, if ſuch examination does not afford any proſpect of gain, or arreſt his attention by its beauty, or uncommon appearance? Laſtly, who is the perſon diligent enough to ſet down, and regiſter his obſervations? the omiſſion of which, will ever render any part of natural hiſtory uncertain, and defective.

CHAP. V.

Of the PRODUCTION and GENERATION of the PYRITES.

WITH reſpect to the origin of the *pyrites*, it is propoſed to conſider the three following particulars. 1. At what time. 2. From what principles. 3. In what manner it was produced.

As to the firſt, it is highly probable, that the *pyrites*, as it now lies in the boſom of the earth, did not all originally exiſt from the creation, but that moſt of them have been generated at different and ſucceſſive periods; which generation will, in all likelihood, continue to the end of all things. It is alſo probable that minerals, in general, conſtituted no principal part of the firſt creation, as the common diviſion into three kingdoms would ſeem to inſinuate; but are to be conſidered rather as ſomething incidental, produced occaſionally, as the opportune concurrence of proper materials have ſerved that purpoſe: not but that within the term of the Moſaic creation, both the ore-matrixes, as the firm rock, or ſtone, and the ores, and native metals began to be produced; and ſo far we may well affirm minerals to have been created: yet, to ſpeak

more

more preciſely of the nature and original of the mineral kingdom, from reaſon and experience, we ought not to aſcribe to that period all the mineral veins and fibres, we either know or conjecture to exiſt in the earth; nor ſhould we imagine, that the veins of ore were at the firſt formed.

Doubtleſs, at the very beginning, actual ore has been generated in the deepeſt and innermoſt bowels of the earth, or has there firſt taken its riſe: ſeeing the ſea, that univerſal, powerful, and indiſpenſably neceſſary mean of mixtion, compoſition, coction and maturation, had at the very firſt penetrated into the depths of the earth; and thus, both in the moſt effectual and proximate manner operated thereon; as plainly appears by the veins of ore already ſought for, and diſcovered; theſe being always found ſo much larger, by how much deeper they run, and becoming ſmaller as they approach the ſurface; the roots and principal trunks of theſe laſt being to be ſought for below. And as to roots, trunks and large branches, reaſon clearly ſuggeſts, that theſe principal parts ought to be aſcribed to the firſt creation: and no leſs probable is it that thoſe principal veins alſo, that have at any time been ſunk for and diſcloſed, tho' not reaching at furtheſt to above 600 fathom deep, or even not to half that depth, may reaſonably be derived from that period. Nay, very ſmall veins and ſeams, eſpecially if ſhooting from larger veins, and theſe again from the largeſt of all, may not unjuſtly be refered to the ſame origin; yet without denying their continuing to ſtretch, and, as it were, ſtill ſhoot out into new ſprouts.

Now, if we find the *pyrites*, not only an univerſal indicant of ores, but alſo at the greateſt depths, nay moſt properly there, we muſt allow it, as we do other ores, and even preferably to them, to be as old as the creation. But ſhould any one

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from concomitant circumſtances infer the *pyrites* to be the mother of all other ores, he would be convinced of his miſtake, upon being appriſed, that tho' they attend upon, they never are derived from each other. Neverthleſs, ſome preference is ſtill due to the *pyrites*; particularly its martial and ſulphureous parts are ſuch earths, as are proximately derived from the undetermined, ſimple earth, and to which they proximately agree. The ſulphur is originally contained in ſuch a manner in the crude, eſpecially the ſlimey and bituminous earth of the ſea, that to its introduction into the compoſition of *pyrites*, it need only be educed and not tranſmuted. And tho' between bitumen and common mineral ſulphur ſome diſtinction may be obſervable; yet, 1. they are very nearly allied; again, 'tis the iron, not the ſulphur, which conſtitutes the principal, nay the ground-part of *pyrites:* and in regard to the metallic earth, no ſort of ore or metal has any thing in it, between which and an unſpecificated crude earth there is ſo near an affinity, as might be ſhewn in *pyrites* and iron-ſtone. Hence iron is educed without difficulty from loamey, clayey and the like fat earths, by the acceſſion or addition of the *phlogiſton* conſtituting metals: which cannot ſo eaſily be effected for other metals, without mixing the earths employed with other things, and eſpecially without a previous long appropriation, and taking a tedious compaſs about. And the iron-earth of the *pyrites* called *ochre*, ſo nearly reſembles a common, eſpecially a loamey earth, in texture and gravity, that it may well be deemed an earth immediately derived from it: and often their colour is ſo much alike, that the one might be eaſily taken for the other. In ſhort, there is no metal, to whoſe conſtitution an univerſal crude earth more readily and nearly ſuits, nor which ſo eaſily reverts

reverts to earth, as iron. Now as iron is the ground and principal, conſtituent part of *pyrites*; it follows, that the *pyrites* (together with the unſulphurated iron-ore, or iron-ſtone) is the moſt proximate, metallic ore, which in the beginning might have ariſen from an unmetallic, unprepared earth.

True it is, there are earths, which quickly bear metalliſation for gold, ſilver, copper, lead and tin. But in the firſt place, 'tis here particularly to be heeded, whether for inſtance they conſtitute, as is pretended the gold and ſilver clays, or whether they contain only very tender and unobſerved eyes or ſpangles of theſe metals: again, whether, tho' generally cryed up for their gold and ſilver, they yield only a very ſmall matter thereof; as iron itſelf, eſpecially if noble veins join or accompany its ore; or if in the iron there be pure native ſilver interſperſed, it may be ſaid to contain gold and ſilver; but this is not the queſtion. Further, it deſerves enquiry, whether the gold and ſilver *yields* of *finters*; or, thoſe marley, ochry, talcky, and calcarious earths, fermenting and exuding from fiſſures, both in the groove, and often at the *day*, conſtitute their internal, proper mixtion, or only adhere externally, as in a *heap-work*; and thus mixtion and aggregation is here to be well diſtinguiſhed; ſeeing, 'tis well known, that ores, nay native grown metals, do, by means of their *weathering*, loſe their bed, and in length of time, ſometimes their ore and metallic form, and revert to an actual earth; the ſilver to a white, the gold to a blackiſh and grey, which is carried off in a tender earth, in a fluid form, by the waters; and the former never, the latter often obſervable by the eye; and in general, on account of their great degree of tenderneſs with difficulty, if at all ſeparable in the buddling or waſhing

waſhing trough. And as the univerſal, crude earth, not as in the groove, but as at the *day*, ſeldom amounts to any conſiderable gold or ſilver *yield*; iron, on the contrary, is every where to be found in marl, clay and loam, being very tender bodies, and conſequently the beſt adapted for metalliſation; and in all underturf, or garden earth infallibly, and that in conſiderable quantities.

'Tis alſo true, that we muſt not deny crude earth ſometimes to yield copper, lead and tin; yet more rarely than it does iron. Beſides, the tin, that might be collected from the upper crude earth-layers, is not from that earth as ſuch, but from the tin-ſtone, and *ſhoads* and grains mixed therein, and thus educed, as from *ſtream-works*. But according to Tollius's and Barba's opinion, it ſhould be an earth, not only holding, but alſo generating tin: as the former obſerved not far from Joachimſthal near Gotteſgabe on the confines of Bohemia; and the latter, at Potoſi*; tho' inſtances of this ſort are extremely rare. Of copper I have no ſuch examples, if we except the coppery *gurs* or juices in mines, as ariſing from nothing elſe but diſſolved, crumbled, vitrioleſcent *copper-pyrites*, and precipitated copper-ochres or ruſt, alſo æruginous clays or marls, which have their colour from diſſolved copper. And that extremely beautiful ſmeary Siſkin-green, to be met with near Tſchopau, deſerves a peculiar examination.

As to lead, beſides the native grains from Maſlaw in Sileſia, I have had no other inſtance, beſides what the very leady clays of the Rautencrantz at Johan-Georgen-ſtadt, there called *lead-ſpat*, afford, and what ſometimes *breaks* here at Friberg,

* Tollii Epiſt. itiner. pag. 96. Barbæ Bergbucklein, pag. 114.

Friberg, at the Tſcherper and at Tſchopau, in colour ſometimes approaching the rare white-grey, and often to the extremely beautiful green lead-ore: and therefore this leady earth, which is ſomething very uncommon, and hitherto only found in formal veins at the due depth of ores, is to be conſidered as an earth, already peculiarly prepared for particular metals, nay almoſt as a lead-ore: beſides, we may conclude from the vein, which has its *ſelvages* entire and cloſe, and from the extraordinary *lead-yield*, often amounting to 20 pounds the quintal, the vein was formerly an open fiſſure, and this leady clay, as a fluid *gur*, derived from a lead-ore, *weathered* and reduced to earth. Nay the univerſal, upper fatty layer of earth comes near to the conſtitution of iron, ſo that theſe particles of it ſwallowed up by plants, loſe not their fitneſs for metal, but according to M. Lemery's experience, are reducible to a genuine iron, as will plainly appear by the magnet.

Converſely it alſo holds, that all metals are again reducible to earth, yet none more ſo than iron, as it uſually falls entirely to ruſt, ochre and earth by the bare moiſture of the air; whereas for the corroſion of copper a longer time is requiſite; and for lead and tin ſcarce the longeſt term ſufficient: the nobler metals, as fine gold and fine ſilver, neither air nor time ſeem capable of affecting in the leaſt. No other metal is affected ſo ſoon as iron with the weakeſt *depart-waters*, which ſcarce touch other metals; nor are any ſo eaſily reducible to the form of earth, as iron. This may be proved by employing the ſame *additions* for the metalliſation of metallic earths, and *calces*. To which may be added, that no metal ſo readily becomes vitrifiable, or is brought to the higheſt degree of a perfect earth. Whence the *pyrites* is indiſpenſably neceſſary in the buſineſs of ſmelting,

ſmelting, in order to the act of ſcorification or vitrification, as this laſt operation is for metalliſation. Upon the whole, in iron the metal and the earth ſtand ſuſceptible of the quickeſt, eaſieſt and moſt repeated changes. 'Tis the firſt metal, that may be, and, proximately, is made from crude earth; its earth is the firſt form of all metallic earths, derived from the univerſal crude earth; whence as iron is the ground-earth of *pyrites*, this laſt ſhould ſeem not improbably to have its original as high as the creation. And naturaliſts deviſing another arrangement of metals than that taken from the planets, ſhould give iron the preference, at leaſt with regard to priority of exiſtence, if not of derivation; for by the common diſpoſition of the mineral kingdom, one metal is groundleſsly ſuppoſed to be produced from another; for inſtance, copper from iron, gold from copper, and in this caſe from *pyrites*, and in the language of miners, from mocklead and glitter; a more mature from a more immature, and a noble from an ignoble metal.

To determine the particular time or day, on which the ſubterraneous kingdom took its riſe, or arrived at its ſtate, ſeeing we learn this neither from Moſes, nor any other inſpired writer, is perhaps no very eaſy matter. That actual mineral, metallic *mixts* ſhould, before the ſecond day, lie confuſedly huddled together, ſeems not very probable.

On the ſecond day, the dry land, as Moſes calls it, began to appear, out of the chaos, and acquired its form. Now from this, and particularly the third day, on which the earth was by an expreſs *fiat*, made fit for the production of vegetables, it is ſcarcely to be doubted but that the earthy particles were hereby multiplied, and the tendereſt of them formed, by means of the water, for vegetation; and the more denſe, heavy particles,

ticles, rendered in ſome meaſure fit for the production of ores and metals: from ever varying circumſtances and cauſes, the ſeveral ſpecies of ſtones and ores were ſtill more and more multiplied, and have appeared in the diſorder and confuſion we now find them.

Minerals cannot be put on a footing with the two others kingdoms; as they conſiſt moſtly of dry, but vegetables and animals, of humid particles: the latter may, in ſome ſort be ſaid to be ſelf-produced, ſeeing what they take in for food, is, as if by a ferment, aſſimilated to their juices; whereas minerals grow by a bare external accumulation; wherein every accretion is applied in layers, ſomething like what appears in the cryſtalliſation of ſalts, and in the *pyrites weathered* on *druſe*: and what is thus once accreted never comes into motion, or if it does, not without the deſtruction of the ſubject. The encreaſe of bodies happens alſo in very different ways; vegetables and animals being regularly produced from ſeeds and eggs; but minerals in no ſuch way, no one *pyrites* being thus to be ſhewn produced from another, but at this day neceſſarily ariſing from the very ſame principles with the original *pyrites* at the creation; or from *diſſolved* or *deſtroyed pyrites*; and thus from *pyrites* and ores reduced to their firſt principles, whatever alchymiſts or others may alledge to the contrary. Earth is the mother, and ſhe paſſive; on the contrary, water, as being active and what muſt impregnate, may be called the father.

I wave at preſent, inſiſting on the prejudice accruing to our knowledge of nature from that very unequal diſtribution into three kingdoms; as thereby we acquire a very falſe, or no notion at all of nature, and are apt to run into falſe concluſions about her. If minerals conſtitute no ſiſter kingdom,

kingdom, but be an eſſential part of their common mother, the earth, how can we pretend to limit their origination to a certain day or period of time, and rather not allow their having exiſted, in their principal part, from the beginning, and probably from the third day of the creation; tho' afterwards, from time to time, they were extended and became more firm and ſtrong.

The deluge is an event, which has produced the moſt remarkable alterations in the earth, that have at any time happened, and to which many effects, obſervable at this day, are to be aſcribed. The hiſtory of the deluge gives great light towards the knowledge of nature, and the preſent ſtate of the earth ſeems to verify this event: by the violence of the deluge the mineral kingdom was thrown into confuſion, parts before conjoined were ſeparated, ores and veins diſlodged, and new beds and poſitions given them. The ſeveral *ſtrata*, wherein minerals are at preſent found, afford convincing inſtances, as well of the truth as of the confuſion wrought by this event, eſpecially in parts where clay, ſand, ſhiver, ſtone and the like, lie in beds and layers on each other. For inſtance, at Waldenberg, in Miſnia, famous for its earthen veſſels employed for diſtilling and other purpoſes. Firſt, beneath the under-turf earth, which is alſo ſtony enough, a coarſe, ſtony ſand lies; underneath this again, flints, of the ſize of hen-eggs, and above theſe a clear white ſand. Thirdly, a middle ſand, wherein are neſts of *black-ſtone* with *ſtone-marrow*. Fourthly, that extremely fat, clear clay, from 2, 3, to 3¼ *German* ells *mighty* or thick; and from the under-turf earth, from 10 to 20 ells deep; from which our ſmooth earthen pots, jugs, and the like veſſels are prepared. Fifthly, underneath this, appears a leaner, namely, a ſandy ſort

of

of clay, about an ell *mighty*; uſually employed for making retorts, and the like veſſels, that are to endure ſtrong open fires. Sixthly, a grey ſand layer, the depth of which is hitherto unknown. This account, together with ſamples of the *ſtrata*, I had from a perſon of reputation, living on the ſpot. Now here the *ſtrata* are not diſpoſed, as if an effect of the flood, but quite in an inverted order. It is alſo very remarkable of the Eiſleben mines, according to M. Mylius *; that we find, 1. The underturf earth reaching from three to four fathom deep. 2. Loam. 3. Red clay. 4. Blue clay. 5. Fine ſand, a fathom and a half deep. 6. Red ſand-rock, three fathom deep. 7. A quaggy, ſoft layer, twelve fathom deep, but not in all places. 8. A looſe, ſpungy layer, three fathom deep. 9. The aſhes, three fathom deep, quite to the rock: tho' theſe layers have happened to be diſpoſed tolerably well in reſpect to gravity and lightneſs, coarſeneſs and fineneſs. In other parts, tho' not in all, of theſe mines, the firſt layer is Sod. 2. Earth. 3. Loam. 4. A ſort of common round ſtone. 5. Coarſe quick-ſand. 6. Red quick-ſand. 7. Yellow quick-ſand. 8. White quick-ſand. 9. Black vein ſtone. 10. Brown wood-vein-ſtone. 11. Red vein-ſtone. 12. Red clover. 13. Red ſeamy vein-ſtone. 14. Coarſe lime-ſtone. 15. Lime-ſtone. 16. Specular lime-ſtone. 17. Clay round-ſtone. 18. Looſe ſpungy-ſtone. 19. *Kneiſs*, &c. And tho' many *ſtrata* of earth may have taken their natural poſitions, yet they never conſiſt of entirely ſimilar particles; and in the chalk, alſo in the fine clay of Waldenberg are found pieces of the black and grey chalcedon or common flint: yet the deluge has cauſed great alterations on the ſurface; as having here covered a country with pure ſand, there with ſlime; alſo introduced ſuch a degree of confuſion, ſo as to make it ſcarce poſſible for each *ſtratum* of earth to be

* Mylii Saxon. ſubterr. P. I. p. 10. & ſq.

unmixed with any other, but for the moſt part to lie huddled and confounded together.

For, we are not to ſuppoſe our globe to reſemble a trough, or the like excavated figure, wherein the variouſly mixed earths are to be regularly diſpoſed, as in the operation of buddling or waſhing ores, but to be of a ſpherical arched form; where the waters, as on a hanging bottom, powerfully rend and pull it aſunder; and this force of the waters we may ſuppoſe to be greateſt at the beginning, and end of the deluge.

And here we have two circumſtances in particular to conſider, (1) That the *deeps* of the earth (the cavities and veins being not only broken, but enlarged) were filled both with the bituminous ſlime of the ocean, the various ſorts of earth of the upper ſurface, and alſo, with the parts of vegetables and animals. (2) That ores, ſtones, and minerals, were not only driven inwards by the elevation of the under-turf earth, but alſo outwards to the *day*, by the eruption of the waters of the abyſs, and thrown into and among the under-turf earth; as will appear no ways improbable, from conſidering the violence of the burſting waters, and that prodigious load of ſea impetuouſly rolling to and fro on the ſurface. Can it with reaſon be pretended, that before the deluge any vulcano's exiſted? or can their origin be aſcribed to any better cauſe, than that, excluſive of the commonly allowed parts of animals and vegetables, it alſo ſerved to ſupply the bituminous matter of the ſea, as ſo much new fewel ſuperadded to the ſulphureous inexhauſtible load of ores already lodged in the bowels of the earth: and further, ſeeing *volcanoes* are never found except near the ſea, may not that immenſe maſs of undeveloped materials ſerve for inceſſant ſupplies to their production?

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In and under the upper layers of earth, ores appear to have been ſometimes broken off from another place, puſhed forth and ſhattered to pieces; ſometimes they have been found complicated, and at other times ſcattered about, partly in banks or earths newly turned up, as in ſo many prepared ore-matrixes: and I ſhall leave it as an undetermined opinion, whether the belief that by the deluge actual head ore-veins, or large conſtant veins have been produced, be quite ſo abſurd?

And firſt, as to *ſhoads*, or broken fragments of veins, we are not in the leaſt to doubt of their being aſſignable to ſome violent alterations, of which the deluge alone can properly be ſuppoſed the cauſe. And this ſeems no ways improbable, from the effects of ſmall torrents, in looſening and carrying minerals up to the *day*; this appears from the gold ſpangles and grains in ſome rivers, as in the Schwartze in Thuringia, the Goldſche in the Voigtland, and other waters; in which we often find the minerals themſelves ſhew that they were forced away from veins. And, doubtleſs, we might alſo find the ores of other metals, were we as diligent in ſearch for them. Great floods exert a ſurpriſing force in vallies, on oppoſing banks and walls, nay, on rock itſelf; huge fragments of them being often rolled to a great diſtance. But what is all this, in compariſon to the mighty effects of the deluge, which has tore out of the inmoſt bowels of the earth, and from depths we can never hope to reach, ores and rock? at the ſame time, the fountains of the deep were conſiderably enlarged. Now, as the ores happened to lodge accidentally here and there in the earth, and were occaſionally of one and another ſort, cloſe and ſpungey, near to, and at a diſtance from the great flood-fountains, ſo alſo the *ſhoads* chanced to prove either poor or rich.

This, certainly, muſt be allowed, that theſe ſhoads generally contain tin, or iron-ſtone, or both together; at leaſt, no *ſtream-work*, conſiſting of pure *ſhoad*, is hitherto worked for other metals. If *pyrites-ſhoads* are not always found in the under-turf earth, this may be owing to our want of care in examining the upper earth in its ſeveral beds: for, as to *pyrites* in *flat-works*, we have plenty, both *bed* and *neſt*-wiſe, generated either ſhort, or long after the deluge, as ſhall appear below. And at Wiera, not far from Neuſtadt, on the Orla in the Oſterland, a *copper-pyrites* was accidentally found, in digging for a cellar, at the depth of a fathom and a half; alſo in other parts thereabouts, upon digging down from the *day*.

Now this ſupplies us with ſome circumſtances particularly meriting attention. (1) That in this caſe we obſerve neither *flat-work*, nor vein, in which the ore ſhould take its direction. (2) That the ores are not immediately dependent on, or connected with each other, but appear in piece-meal; and though at no great diſtance aſunder, yet, by the interpoſing under-turf earth, are often greatly divided and ſcattered. (3) That theſe pieces, though happening to lie pretty cloſe together, never exhibit any appearance of their having ever been joined, as we often meet with veins, where the ore is cut aſunder with fiſſures, and theſe fiſſures ſo ſtuffed with *gurs*, as if, by their means, the parts had been ſeparated to a greater diſtance; but then, in this caſe, a curious eye diſcovers the parts to have been once joined, and that they plainly formed together an actual vein. (4) That theſe copper ſamples ſhew edges and corners ſo ſharp, that if we ſuppoſe the place they are found in, not to be that of their birth, yet it could be at no great diſtance off, if we conſider that ſuch broken fragments may, by rolling, become ſmooth, and wore round.

But

But we need not go ſo far for inſtances; ſeeing in the *tin-ſtream-works* of Friberg, the *tin-ſhoads* are often intermixed with *pyrites*, as ſmelters find to their coſt. Should we allow the *pyrites*, from its ſuppoſed univerſality, to manifeſt itſelf in many places as a *ſhoad*; yet it muſt alſo be allowed, that this mineral, above all others, is moſt ſuſceptible of deſtruction, and of becoming an earth again; eſpecially if lying near the *day*, and thereby more expoſed to the action of the air; ſo that in the courſe of ſome thouſand years, many teſtimonies of the deluge may be quite effaced. Further, that this ſurmiſe is not without foundation, may be concluded from the ruſty ſpots and neſts found in many places; in particular, thoſe in ſand ſtone, ſhew remains and tokens of *weathered*, or deſtroyed *pyrites*. Nor are we to wonder, that *copper pyrites* is more commonly to be met with than *iron-pyrites*; ſeeing the former is generally more durable and laſting, if not ſometimes indeſtructible.

Again, it will be no difficult matter to form a judgement, and ſhew the weakneſs and inſufficiency of the remarks generally made on *ſhoads*. Thus much commonly holds true, that, the ponderous and moſt metallic ſort cannot eaſily remain near the ſurface, but muſt ſink down. Concerning pieces of ore which happen to be ſmooth or ſharp, we may probably conjecture, whether the vein, whence they came, was at hand, or at a diſtance: if the ſtone thereof, or of the adjoining mountain, be the ſame with that of the *ſhoad*, we may imagine the vein to lie there, and there we may work for it; and *ſhoads* in high mountains, and on eaſy declivities, are more eaſily come at. But every one ſees how fallacious ſuch indications or directions are; for ſuch broken fragments may, in a tender bottom, be driven to

a ſufficient diſtance, without having been in the leaſt broke off, or ſmoothed.

I muſt not omit mentioning, on this occaſion, that uſually, under the title of *pyrites-ſhoads*, we alſo include the *ſquats*, or *flat-works*, which are commonly *copper-pyrites*, and juſtly; as theſe, with their upper and under earth-layers, are couched in *ſtrata*, one upon the other. To this Lohneiſs refers *, when he ſays; 'we alſo find 'ſquats, which extending in length and breadth, 'often take in a large compaſs of rock, which 'we call *ſhoad*, &c.' but with this remarkable difference, that on ſuch *flat-veins*, not the ore itſelf, as is the caſe with the *ſhoads* hitherto deſcribed, but only the earth, whereon afterwards the ore comes gradually to be generated, is thus couched and laid.

As to *flat-veins*, theſe, in regard to their origin from the deluge, deſerve a quite different conſideration. Sand-ſtone, lime-ſtone, marle-ſtone, and ſhiver, which generally form *ſquats*, plainly manifeſt, upon a ſomewhat more accurate inſpection, that they are a concreted ſand, or hardened earth. The ſeveral figures of herbs, wood, bones, ſhells, and fiſh, are far from being *luſus naturæ*, or fortuitous images, but are, in part, actual bodies, ſomehow or other conveyed thither, or, at leaſt, the impreſſions of theſe bodies. This I have ſhewn, from ſeveral circumſtances, in my *Flora Saturnizans*; particularly from the nature of their beds or matrixes, from that of the bodies themſelves, which are commonly durable, hard, and ſtoney. And here I muſt rectify a miſtake I was there under; namely, in not allowing the *hyſterolithos* to be an actual ſpecies of muſſels, and doubting about the *gloſſopetræ* being the teeth of ſea-dogs;

* Berg-baa-buch.

dogs; but now I am fully convinced of the certainty of both: of the former, from a particular treatiſe of M. Verdries; and of the latter, from many inſtances; in particular, from my own inſpection of a ſample, to which there ſtill adhered a piece of the jaw, in the poſſeſſion of Dr. Buttner, of Chemnitz. Further, from the ſubſtance and nature of ſuch foſſile bodies, remaining, often, quite unaltered, their origin is plainly manifeſted; alſo from the *mixt-works*; and, laſtly, from their irregular poſition; in reality, not owing to their natural tendency, but to ſome external, irreſiſtable force; whence it is no improbable concluſion, that nothing leſs than the univerſal deluge could have buried the parts of animals and plants at ſuch a depth in the earth.

Now as both the *copper-pyrites*, and alſo the often intermixed *iron-pyrites* flat-work lie in, under, and above ſuch petrified remains of the deluge, how can we *here* poſſibly go ſo far back as the creation, and *there* begin with the deluge, or call in queſtion the exiſtence of ſuch ore in that very place and ſpot before, and only allow its having ariſen firſt of all after the deluge? three circumſtances which, if not entirely convincing, yet, being of ſome weight, render the thing probable.

The firſt regards the *ſtrata*, or beds of earth, conſtituting both the under and upper bed of the *pyrites*; ſome of which I have before mentioned, from M. Mylius, and others: theſe lie in different forms, in various ſhelves, or *ſtrata*, *cover-wiſe*, one over the other; which we may juſtly attribute to an horizontal, or level motion, and this motion to a floating or wavy flood. The undermoſt often reach to 10, 20, 30 fathom, and more; ſo that they cannot be aſcribed to any partial or provincial inundation: and laſtly, they ſhew their ſe-

paration from the *terra firma*, or that bottom, which before the deluge conſtituted either the upper ſurface, or was, by means of the deluge, firſt tore up, and laid bare.

The ſecond regards the nature of the *ſquat-ſtone* itſelf; for now to mention only *ſhiver*, in which the *pyrites ſquat-veins* are moſtly diſcovered, we muſt needs ſuppoſe them to have been originally a water-ſlime, gradually arrived to a leafy or flakey ſtone, as was above ſolidly deduced from the extraneous matters found therein; it being impoſſible they ſhould have their preſent degree of firmneſs and hardneſs, and at the ſame time receive ſuch matters as theſe: and the nature of *ſhiver*, eſpecially the aluminous, might ſerve not a little to eſtabliſh this, as being inflammable, and like a fatty ſort of ſlime; nay, not unuſually manifeſting in the fire, a flame, and odour like amber and bitumen. Nay, 'tis hard to ſay, whether (3) this other circumſtance may not be allowed ſome weight, namely; as lime-ſtone ſo readily break near *ſhiver*, and are, above others, of a ſaline nature; again, as lime-ſtone, ſhiver, and ſtone-coal, are not eaſily to be found, the one without the other; alſo, as lime-ſtone has actual ſtone-ſalt lodged in and upon it, of which we have a ſample at Bottendorff, in Thuringia: laſtly, as the ſea, particularly in its depths, abounds with ſaline, bituminous, and ſulphureous particles: and beſides, as ſalt and ſulphur, ſulphur and ſalt, ſalt and earth, ſtand ſo proximately convertible; ſhould we not, from all this, conclude, that ſhiver, ſtone-coal, and lime-ſtone, may have had, from the ſea, one common cauſe, both of their mixtion, conſtitution, and bedding?

And as ſuch *flat-work* ought not to be derived from the creation, ſtill leſs is it to be conſidered as a genuine *ſhoad*, or *piece-meal-work*, thrown together

gether in a heap; in regard it not only, tho' cut through with croſs ſpads, fiſſures, and minerals, hangs together like a thread, but it alſo often appears ſhattered and tender as hair; the deluge, firſt, only ſupplying the proper ſlimey earth, as the ground, or baſis, which not only became full of fiſſures in the drying, but is in itſelf alſo an accumulation of a ſpungey and eaſily penetrable matter. In the fiſſures, the *ore-weatherings*, or damps, have found ingreſs and lodging; but in the particular ſort of the earth, found a well prepared, alſo an expanſile matrix; and for this purpoſe, nature has had a ſufficient ſpace of time, as being what was highly requiſite; but why ſhe has excluded or produced no other ore but *pyrites* chiefly, in particular, *copper-pyrites*, is indeed a queſtion we are as little obliged to reſolve, as the remote cauſes of things are beyond our inveſtigation: however, a cauſe may be aſſigned, on which we may beſtow the following reflections.

We find both earth, *heap-work*, and ſtone, nay, ore too, in layers. Of the firſt we have, every where, inſtances enough; particularly in ſand, loam, and clay-pits. Of ſtone there neither is, nor can be ſo much known; ſeeing both our experience and accounts thereof are lame and imperfect. In ſtone-quarries, however, we plainly obſerve layers; yet, commonly, not ſo often of a different, as of a ſimilar nature, where neither complexion, nature, nor colour, exhibit peculiar layers, only the ſeams form different flakes and tables, the whole maſs of ſtone having only a cover and bed of a harder nature. Again, in complexion, and thus in admixture, alſo in nature, namely, ground-mixtion, appears a difference of the ſtone layers; as quarry-ſtone, ſand-ſtone, lime-ſtone, *&c.* may well lie interchangeably together: and not only in theſe large *ſtrata* of earth and ſtone,

ſtone, which take up a large compaſs, but alſo in peculiar ſmall ſeams and veins, traverſing ſuch large *ſtrata*, often various layers are obſervable.

Of this miniature *flat-work* ſtone, if I may ſo call it, we have an extraordinary inſtance, at Friberg, in the uncommon jaſper, or coral ſtone. For, there we have (1.) a white, heavy ſpad. Under this (2.) a ſmooth mountain-cryſtal, both of them from 1 to 2 inches thick. (3.) Amethiſt. (4.) Again, mountain-cryſtal, or *quartz*. (5.) Jaſper. (6.) Mountain-cryſtal. (7.) Jaſper. (8.) Mountain-cryſtal. (9.) Jaſper. (10.) Cryſtal. The former eight layers are often only the thickneſs of a fine thread, and all together ſcarce exceeding ½ inch, and yet very diſtinct. (11.) Jaſper, of a bright red. (12.) Jaſper, of a dark red. (13.) Chalcedon. (14.) Jaſper. (15.) Chalcedon; nay, the two laſt, once or twice more, alternately. (16.) A firm horny quartz. The laſt ſix or eight grow ſtill thicker and thicker, the jaſper there being often an inch thick, and above. Theſe layers of precious ſtone, which are extremely beautiful to the eye, cohere very firm and cloſe together, ſo that the entire ſtone bears ſplitting tranſverſely, better than in the ſeams; and then they lie not ſo flat in ſhivers on each other, but vaulted one over the other, with ſmall arches, ſo that the thickeſt layer of jaſper may be clearly ſeen to traverſe moſt of the upper layers, till, at length, it gradually loſes itſelf: yet there the jaſper-layers are moſt eaſily ſeparable where thickeſt, alſo where the chalcedon is thickeſt: and as it there exhibits pure round eminences, ſtanding cloſe to each other, like ſo many little balls cut aſunder, whoſe concavities lodge in the chalcedon, it is here, at Friberg, commonly called *coral-ſtone*. In particular, the violet caſt of the amethiſt, and the red bluſh of the jaſper, whereby it comes to reſemble coral, would

would ſeem to ſuggeſt an enquiry, whether their tint be not owing to the ſhare of metal they contain. I know not, whether the amethyſt does not hold gold; as there is no experiment extant for giving ſuch a violet colour to a ſtone, or ſtony glaſs-flux, except by the means of gold, with the addition of tin; eſpecially, as I have a method of imparting this colour laſtingly to ſpring-water, without making it leſs ſweet and potable, from gold, without tin, or any other mineral, or metallic body, barely by means of a certain ſalt. As to the jaſper bluſh, I would mention iron, as, at leaſt, the earth of this metal eminently carries this colour; or even gold, either ſeparately, or jointly, with the former, none of theſe circumſtances being inconſiſtent with the nature of things. All this I propoſe as conjecture only; for tho', indeed, neither gold, nor any other metal, is, by analyſis, or reſolution, educible from ſuch amethyſts, *quartz*, and *druſe*; nay, is as little poſſible, as that the leaſt trace of a metal ſhould be manifeſted by the quickeſt, moſt tender ſcales, in artificial, variegated fluxes and glaſſes, from the metal being widely diſperſed; and to be educed from glaſs, a body the moſt tender and retentive, and to be exhibited in its metallic form: yet, *ſyntheſis*, or compoſition, gives ſome countenance to the conjecture; namely, as the well known gold-purple, or the gold powder, made with tin, bears being introduced as a violet colour into glaſs, nay, into a common water: this I the rather mention, ſeeing in chemiſtry, and according to the doctrine of nature, the proofs from compoſition are preferable to thoſe from reſolution. But be this as it will, the different *ſtrata* in this jaſper-ſtone manifeſt ſomething different, if not in the ground-mixtions, yet in the degrees of the coction and maturation of the mixts; the *ſtrata* not being produced externally in couches,

couches, in the ſame manner that floods may be ſuppoſed, from time to time, to accumulate different layers of earth, ſand, *&c.* on each other, but ſpontaneouſly, from a vaſt number of earthy particles, in the way of a precipitation, both by means of the ſubterraneous inſtruments of maturation, and thoſe of the moiſt, warm air, this ſtone ſtriking out quite to the *day*.

For, there is no one *ſquat*, where a flood, the moſt partial imaginable, can be exhibited as a cauſe; but dipping into the *deep*, and ſtretching, as it does, into the *field*, it is over-laid with the abovementioned variegated ſtone; in reſpect of which it may rather be called a vein: and accordingly it takes its riſe from the bowels of the earth, and, probably, in the way of an exudation, or fermentation; at the cloſe of which, the refuſe, like dregs, ſeparates upwards and downwards, the nobleſt parts remaining in the middle.

Yet, not to digreſs too far, we muſt here diſtinguiſh between thoſe *ſquats*, once really formed by the waters of the deluge, and thoſe ſpontaneouſly and gradually produced before or after it, barely by length of time. The former are either unchanged earths and ſands, or become firm, and thus turned to ſtone, as the ſhiver and ſand-ſtone, chiefly here at Friberg. The latter are partly the harder and cloſer ſort of ſtone, as *gemſs*, *knauer*, and all thoſe banks, or ſhelves, chiefly coinciding with the deeper under-lying ſtone; partly fermented, or exudated, petrified, mineral juices. Of the ſecond ſort, being, at preſent, foreign to our purpoſe, we ſhall treat hereafter. As to the firſt, we ſhall now offer ſome anſwer to the queſtion ſtarted above; namely, why, in the *deluge-ſquats*, we commonly find the *pyrites*, and, more frequently, the *copper-pyrites*. Tho' this queſtion may ſeem ſomewhat premature, conſider-

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ing the ſmall depth of earth we have hitherto had occaſion to lay open; our experience, however, reaches thus far; that what lodges in ſhiver, is *pyrites*, and that at all times. We here ſpeak of capital *ſquat-works* as of veins, over-looking, as of no account, the inter-current ſmall fibres of *glitter*, and ſmall interſperſed eyes of ore: for, where was there ever a *ſhiver-ſquat* of *glitter* laid bare, where this laſt was the eſſential, conſtituent part, and the *pyrites*, either not at all, or only incidentally in it, as, we know, is the caſe of veins dipping extremely deep? or where did we ever hear of noble veins of *red* and *white goldiſh* ore, *cobald*, *biſmuth*, *glaſſy* ore, and the like, in ſhiver-mines, unleſs in tranſverſe veins?

Pyrites chiefly conſiſts of iron and ſulphur; now we find ſhiver exactly to correſpond in theſe two conſtituent parts of the *pyrites*, if not eſſentially containing them. Above all kinds of ſtone, it contains ſulphur, nay, often that alone; as plainly appears in *alum-ſhiver*, *ſtone-coal-ſhiver*, and the like black bituminous bodies. To the formation of iron all fat earths are adapted, nay, all earths, ſo they be capable of being duly combined with the *phlogiſton*. Iron is the moſt univerſal metal, as I have repeatedly ſhewn already; is the primordial metallic form, producible the moſt readily and eaſily from an earth: iron comes neareſt the nature of the inflammable earth, as appears from its deflagration with ſalt-petre. Sulphur and iron are the two capital, middle mineral, and metal ſpecies, as undeniably appears from all conſiderations, whether œconomical, medicinal, and purely natural; that were we to ſuppoſe any one metal or mineral produced expreſs, theſe two may, above all other ores and metals, be affirmed to be ſo. Again, what is *copper-pyrites* in ground-mixtion, but *iron-pyrites?* and tho', on the ſcore of the

the exceſs of the copper, which may ſometimes amount to almoſt half the ore, it uſually quite loſes the appellation, *iron-pyrites*, yet, the quantity of copper with the iron is inconſtant and variable: for, *iron-pyrites* may well be without any copper, as thoſe of Heſſe, Boll, Altſattel, Toplitz, *&c.* ſufficiently ſhew, but *copper-pyrites* never without iron. And ſhould this be allowed of no weight, yet what has a greater affinity with iron than copper? We have often *copper-pyrites* veins, without the leaſt *lead-glitter*, much leſs any other ore, either attending or intermixed: but where is there any other mine, without a number of different veins, either accompanying or intermixed, and without any *pyrites* at all? Iron and copper cohere ſo firmly together, as often to be ſcarce ſeparable, as the Straſburg undertakers experience to their coſt, at the Lower Hartz, where there lie ſome hundred quintals of metal, as 'tis called, or black copper, holding 56 lb. of *roſe-copper* the quintal, and 4 loths * of ſilver: nor can they, with much more facility, ſeparate the grey iron-ſtone (containing 30 lb. of iron the quintal, and tainting the copper) from the copper-ore. Copper, next to iron, above all the metals (if we exclude zink, biſmuth, and regulus of antimony, and perhaps alſo tin, as belonging to the claſs of ſemi-metals) manifeſts the largeſt ſhare of *phlogiſton*; not to mention other circumſtances, too tedious here to enumerate.

The queſtion may be reſolved by propoſing another, namely, why in other ore-matrixes, as for inſtance, ſand-ſtone, loam, and the like, which, equally with ſhiver, are derived from the deluge, there are not alſo *pyrites-ſquats*. To this the anſwer may be, that all ſuch queries are premature, and ought to be forborn, 'till we can aſſert, they

* A loth is half an ounce.

have

have been duly ſunk, or dug for, without finding any thing of that ſort. In the famous ſand-ſtone quarry, at Pirna, in Miſnia, the common ore-depth has not been hitherto reached; and what pity is it, that ſo extraordinary a quarry ſhould not be more carefully examined? The loam-beds, likewiſe, have equally partaken of the ſame fate; namely, to lie neglected and unexamined.

Now, tho' our experience, which is, hitherto, inconſiderable enough, ſhould ſuffice to give the preference to the *ſhiver*, above other *ſtream-beds*, in regard to the *pyrites-ſquats*, yet it would be no difficult matter to find out ſome reaſon for this difference; namely, thoſe parts proper for the mixtion of *pyrites*, as the fat earth for the ſulphur, and the tender earth for the iron, as has been already mentioned, are found, eſpecially the firſt in the ſhiver, not only proximately prepared for the *pyrites*, but alſo indiſputably in greater plenty than in loam and ſand: and the matrix is not to be conſidered as a bare receptacle, but as a receptacle of proper materials too; that is, the inhalations, or impregnations, called *inweatherings*, cannot alone have their effect, nor their ſupplying their materials produce an ore, unleſs the matrix hold, and reciprocally furniſh alſo, by means of an exhalation, called *outweathering*, its proper matter; that the paſſive may, by means of the agent, come into motion, to form the third body here intended. In loam, 'tis true, a fat earth is contained, from which iron may be, and actually is produced; but naturally not in ſuch quantity, as that the iron ſhould put on the form of a *pyrites*, and it is the ſame with a body over-doſed with ſulphur. In the ſand-ſtone the parts of the whole have too far deviated from the nature of an earth, and arrived at ſuch a degree of hardneſs, to be incapable of a greater remove from the form of an earth, from

which

which orey and metallic particles are to take their riſe: for, this ſtone conſiſts of pure ſand-grains, which are ſo many ſmall flints, and, conſequently, the denſeſt corpuſcles; and like ſo many hardened, indurated matrixes, where the effete materials are, even by the ſtrongeſt influx, with difficulty brought to motion and conception. Yet here ſome might conſider, as oppoſite to this, the commonly flinty and quartzy, nay, horn-ſtony rock of the *ſelvages*, which, in veins, form the caſe for the ore. But, not to mention that objects lying near are not always to be ſuppoſed derivable from each other, tho' they may ſucceſſively, or even ſimultaneouſly, happen to exiſt; the principal reflexion and query here may be, whether ſuch quartzy and horn-ſtoney rock was already become ſuch a denſe and cloſe body, when the ore began firſt to be lodged there? or whether it was not of a moiſter, ſofter, and a more receptible texture, wherein the mineraliſing *weathering*, or damps, might find lodgement, incorporate itſelf, and thus the tender veſſels of the matrix, namely, the tender *ſelvage*, emit ſome material efflux for the production of the ore? The firſt opinion fails, for this reaſon; as it muſt be allowed, that this ſtubbornneſs in the earth was not original, but adventitious; and that ſomething flinty, quartzy, ſandy, ſtoney, glaſs-yieldy, or, in a word, Becher's firſt earth, might not exiſt in metals.

And in thoſe productions of the *pyrites*, for which the deluge has laid the foundation, ſomething peculiar is ſtill to be obſerved: namely, that *pyrites* is even found weathered on bodies at a great remove from the mineral kingdom, and unadapted for it, as wood; of which I have both ſeen and read inſtances. M. Lichtwer of Dreſden, Inſpector of his Majeſty's cabinet of minerals, has a ſmall piece of wood, on which a glit-

tery,

tery, mock-leady matter was not only manifeſtly weathered, but lodged in its rents. This ſample, which was found in 1658 in an old mine at Schwartz in Tyrol, manifeſtly ſhews, it was not only a real unpetrified wood, but alſo the ore ſo cloſely adhering to it, as to exclude the leaſt ſuſpicion of a cheat or impoſture. And this has led me to enquire farther after ſuch ſamples; at leaſt, whether ore may not ſometimes have been found on bodies, tho' of an extraneous kingdom, yet approaching nearer the nature of ſtone than wood does; as for inſtance, on periwinkles, muſcles and the like ſhells, unchanged, unpetrified; though that ſuch parts are alſo petrified is evident from the foſſils of Boll in the territory of Wirtemberg. And I have ſeen the muſcle-work of Wicrau in Oſterland, on the Orla, a mile from Neuſtadt, ſtuffed with ſand-ſtone, in which lead-glitter was implanted deep into the ſhell, but ſtill diſtinguiſhable and ſeparable from the adhering ſand-ſtone; tho' I conſidered it rather in a petrified than in a native or animal ſtate. But we experience this ſtill more in wood petrified, or reduced at leaſt to ſtone-coal; M. Mylius, among others, inſiſts upon having ſeen ſamples of that kind, filled with marcaſite, from the Fiſchbach in the territory of Henneberg; and pieces of wood, reduced to marcaſite, have been found at Leipſick and Bitterfeld, in digging for wells*. Yet ſuch inſtances, where pieces of ſhell or wood are become real ſtone, are immaterial, however extraordinary, in other reſpects, it might be to find lead-ore, near ſuch foſſils, as it would be no leſs ſo to find lead-ore in ſand-ſtone. And tho' there were no ſamples of the *pyrites*, or any other ore to be ſhewn on the unchanged remains of the deluge, yet ſuch might not come to the *day*; of which the above ſample of wood, overlaid

* Saxon ſubterr. P. I. p. 63.

with glitter, appearing but very lately, is a plain inſtance; and as experience ſhews, that many things carried off and buried by the deluge have retained the nature of their reſpective kingdoms undeſtroyed: tho' the bodies of vegetables, in particular, are of ſo watry and changeable a mixtion and texture as to be incapable of any length of duration, they turning either to earth and aſh or ſtone, and thus either degenerating or improving; yet in many places they have preſerved themſelves from corruption: and bones and ſhells have undergone a kind of calcination, and wood a hard exſiccation. I have, however, had ſamples, clearly exhibiting parts of animals, in their unpetrified form and mixtion, ſuffering *pyrites* to grow upon them, and thus rendered ſuſceptible of the action of a mineral weathering or damp; nay even more ſo than in vegetables.

Tho' we might well poſtpone this article to the following paragraph, where it will appear, how the *pyrites*, without any action of a deluge, may be ſuppoſed to be generated barely by length of time, and is ſo at preſent, to ſay nothing of entire large veins; tho' there is a great deal of room to think, that all of them are not abſolutely referable to the creation, as to their origin, but that here and there, amidſt the never-ceaſing, violent working of the huge maſs, there muſt needs have happened large waſtings of ores, and ſpringing or ſplitting aſunder of whole rocks, and that theſe ſtill happening, may be attended with new productions, in order to the filling up theſe rents or gaps: yet having already real teſtimonies enough to verify the opinion of the new production of ore, it would be needleſs to call poſſibilities in aid. In the firſt place, ſinter is found with its glitter and *pyrites* upon it, not only in ſome old mines at Friberg, but alſo in various places, in caves, and even

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at the *day*: by ſinter is meant, in the full extent of the word, all thoſe earths in the *groove*, which, by means of the gentle motion of the waters, work out and exude from the fiſſures (whence they are called *gur* *) and thus accumulate; turning thick and ſmeary, a part hardening to ſtone, and forming icicles, a part remaining earthy and ſoft like butter, according to the difference of times, place, the nature of the earth itſelf, and other circumſtances. The laſt ſort conſiſts commonly of an ochry, yellow and brown ſubſtance, and doubtleſs is only the metallic earths of *pyrites*, ſomewhere or other weathered, or diſſolved; its earth, by that deſtruction, becoming highly tender and light, ſettles downwards on fiſſures, thro' the water, and alſo mounts upwards, in its tendereſt parts of all, to the *day*, as is known to be the caſe of moſt medicinal ſprings. The firſt ſort is more of a calcarious or ſpathy white, not ſo common, and probably derived from ſome ſuch rock, which, if not a pure lime or gypſum ſtone, yet partakes of it; at leaſt, quartz or the like, it cannot be: this we ſee from its reſolution, particularly by its ignition and extinction; where, by the lixivious odour, by the crumbling and extraordinary degree of whiteneſs, it bewrays its origin: again, from its compoſition, when the waters in vaults, and adjoining to walls, (whereof, among others, the great aquæduct, called *halſebrucke*, near Fribourg, is a plain teſtimony) let fall again the lime, unobſervedly conveyed along with them, and re-apply it to the roofs and ſides, in flakes and icicles; yet with this difference, that ſuch a ſinter, as at the *day* even in places, that ſeem pretty cloſe, and yet not altogether ſo, as quite to exclude the air, arrives not to that degree of firmneſs and hardneſs, like what ſuch a one has, that proceeds from

* From the German *gieren*, ſignifying to ferment.

grooves quite run to decay, or not immediately expoſed to the fanning of the air.

Moreover, we are to obſerve this circumſtance, which gives a great degree of probability to our notion of both theſe ſorts of ſinter, *viz.* that the white, like a lime, binds as eaſily as ſtone, which the yellow, being metallic, does not: yet it ſhould be remembered, that we are to except the luty or talky *ſinter* or *gurs*; ſuch as, in particular, are to be met with, very beautiful, on the Himmelsfirſten and Gunther, at Weiſſenborn; but which is not ſo much of a lime, as a grey-ſilver white, and does not petrify. In ſhort, the *ſinter* is either luty, and of a marl-earth; or metallic, chiefly from iron; or calcarious and petrefiable. Of the third ſort, namely, that frequently called *ſtalactites*, or *ſtalagmites*, drop-ſtone, and which muſt be well known from the famous Bauman's cave, is not ſo uncommon in mines, provided we are attentive enough: yet, ſo far as I remember, it is no where found, in the territory of Friberg, ſo plentifully as at the mine called Himmel-farth-chriſti; nor, indeed, can it be ſo common, ſeeing, in the firſt place, old decayed mine-works, and moreover, certain waters, muſt concur to its production; and *there*, upon due obſervation of only the nature of the *ſinter*, the moſt pertinacious in opinion muſt drop the period of the creation for its firſt origination; for, *there* the fiſſures, the ſides, and roofs, are covered over with a ſtony ſhell, or cruſt: nay, what is very extraordinary, the water in a pit of the groove, when full, was covered over with a ſtony cruſt, as with a thin ice, the thickneſs of the back of a knife, and tho' looſened at the ſides, ſtill remained floating upon the water, whence it was called *floating ſinter*.

On ſuch drop-ſtone actual *lead-glitter* has been found, two ſamples of which I have in my own poſſeſſion;

poſſeſſion; and many other inſtances I have obſerved of the production of ores and *pyrites*, even lately: as, a *ſinter* from the territory of Hohenbircke, from the greateſt depth hitherto reached, exactly overlaying a *druſy* lead glitter, and the latter, a *ſinter*, and this *ſinter*, *lead-glitter*, as ſo many pebbles, or buttons, artfully accreted to each other. I am poſſeſſed of a *ſinter*, whereon the *pyrites* is viſible, and in particular, the coppery; nor do I doubt but many more ſuch inſtances may be hereafter met with, when application is made to theſe ſubjects, with more accuracy and attention; — ſo that *ſinter* is ſtill at this day produced in places where before there was none.

It may ſeem needleſs to mention particular inſtances of this kind, ſeeing earth is known to be derived from water, and ſtone from earth. Examples of waters yielding ſtone are very numerous. The Caroline waters at the Prudel depoſite a whitiſh, intermixed with a fleſh-coloured, and throw up a yellowiſh ſtone, firm enough to bear working and poliſhing, like marble; and that in ſuch plenty, that the inhabitants are, at times, obliged, not without great labour, to remove it, to prevent its choaking up the ſpring. At Merana, in the County of Schonberg in Miſnia, there is a ſtone-quarry, where we have a plain inſtance of the ſame ſort: the ſtone is done over as with ſo many cruſts of ice, and directly beneath the under-turf earth huge maſſes of *ſinter* are dug up. *Sinter* continues growing ſo long as that ſort of earth, whereof it conſiſts, is conveyed to it by the waters, and the free acceſs of the waters not interrupted by the entire concretion of the fiſſure, or by other accident. The firſt is evident from all the abovementioned inſtances; in particular, the Caroline ſtone, which may be daily obſerved

accreting more and more according to the things laid therein; alſo to fiſſures and cavities, which often become gradually narrower, and, at length, are entirely blocked up. The ſecond is alſo very plain, as an increaſe always implies a free acceſs; and, as evidently appears, among other things, in *mixt-works*, ſuch as I above inſtanced in from the Hohenbirck groove, where we ſee, that where the ore and glitter, forming *weather* or damps, have, as it were, ceaſed, the ſtone-forming, or petrifying waters, begin to overlay the *glitter* with a cruſt of *ſinter*; and this again ceaſing, the *ſinter* to afford a couch to the *glitter*.

Here I muſt not omit mentioning, that this ſtone forms no layers or ſhelves, tho' its accumulation be by a ſhoving of earthy particles precipitated out of the waters, over each the other; whence it ſeparates, not in flakes or leaves horizontally, but rather upwards and downwards; alſo, in breaking, it manifeſts a texture, ſhewing its increaſe to happen ſideways, by an appoſition of tender threads, almoſt in the manner of the Hungarian *atlas-vitriol*. For, from the *ſinter* from walls, and thus from lime already prepared, which eaſily bears being divided into flakes, we cannot conclude to that which is derived from crude lime-ſtone, and other unknown admixtures. My reaſon for mentioning this, is to obviate ſome miſtaken notions about the Caroline white-coloured ſtone-ſtrata, which are evidently diſtinguiſhable from each other, not only by the colour, as being beautifully ſtriped like a piece of cloth, or fillet, but alſo by their eaſy ſeparation at the coloured parts: and, doubtleſs, the different colours ſhould afford ſomething different in their internal *mixtion*, at leaſt in the proportion of it, upon making a due proof of ſome of the principal *ſtrata*, each apart.

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On this *ſinter* then, thus lately formed, and ſtill forming, even to this day, we find *glitter*, iron and copper *pyrites*, not conveyed by ſtreams of water, nor agglutinated, but *weathered* thereon, or produced by *weather* or damps. This I affirm, to obviate a doubt the reader might otherwiſe entertain, from pieces and bits of ore being looſened either ſpontaneouſly, or by men's hands, from veins, and conveyed along by the waters, coming ſomewhere or other to lodge and fix, and to be concreted, not only by petrifying waters, but alſo by binding *weather*, or damps: and I have had ſamples, where ſuch concretions, by waters, of pieces of ſtone or rock, was very viſible: nor is it any new thing for the damps of ores and ſtone to fill up again the rents and chaps in *vein-ſtone*. The ore on *ſinter* is a plain and eaſy proof in behalf of a *weathering*, or a production by damps, rather than by way of *ſtreaming*; for, (1.) both the *glitter* and the *pyrites* appear in as compleat, cubical, and angular figures, as they do on quartzy and ſpathy *druſe*, where few will readily admit the effects of a *ſtreaming*, and as little doubt of thoſe by damps, as ſhall be ſhown lower down. (2.) I never once met with any one piece of ore, either on *druſe* or *ſinter*, tho' I have accurately examined a great many ſamples, where the piece in queſtion manifeſted any flaw; all of them, even the ſmalleſt bits, having their proper ſmooth ſurfaces and ſides, as the moſt indiſputed original *mixtwork* could poſſibly have. (3.) There muſt needs interpoſe a manifeſt band or cement, either proceeding from the mutual action of the bodies themſelves, or from an external *weathering*, or from water, to bind them together; and yet, between the *ſinter* and the ore no ſuch third body is obſervable to form the band or cement, the ore lying immediately preſſed in upon the ſtone.

In ſhort, the *pyrites* of ſuch places is a new production; and its foundation being but lately laid, how can the ſuperſtructure be ſuppoſed to be of an older date? The *ſinter* manifeſtly is produced as it were before our eyes, and ſhall the ore then, found thereon, be made coeval with the world? *Sinters* claim our ſpecial regard; and, without vanity, I may affirm, that, as far as I know, no one, before myſelf, hath ever made the obſervation of ores growing on them.

This leads us to conſider, whether ore may not be found ſucceſſively generated in *druſe*, in neſts and fiſſures, rather than on *ſinter:* as, (1.) ſuch matrixes are more adapted for the conception of ore, from their flinty, quartzy, and conſequently more appropriated nature, than calcarious, ſpathy *ſinter-ſtone:* beſides, that the *ore-weatherings*, or damps, lie more undiſturbed in ſuch cloſe matrixes, than where the *gur* is in motion. (2.) As there are not wanting *ſinters* in *druſe*, whereon, again, ore accretes. (3.) Should we only conſider, why thoſe *druſe* exhibit, if not always, yet commonly, and very plentifully, their ore, which is, for the moſt part, *pyrites*, on one ſide only; muſt we not thence conclude, that what thus adheres to the *druſe*, did not at the ſame time ariſe with, or ſpring from it? Again, that matters, thus brought together, may have had their origin and flux from that ſide whereon they are found; and, laſtly, that they were applied thereon by *weatherings* or damps? And can we imagine productions, of which often two, three, or more ſpecies are found lying on each other, to ſpring, either altogether, or inſtantaneouſly?

From the moſt unexceptionable experience, we learn the cleareſt and pureſt waters to hold and carry along with them earth; afterwards, to let it fall; further, this earth to turn to ſtone; laſtly, and

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principally, theſe ſtones to prove as cryſtalline and tranſparent as the clear tacks or ſpikes on *druſe*; as appears from the following experiment. Take the freſh urine of a boy, leave it to ſtand for three or four years in a ſtaunch, large cucurbit, about half full, covered over with a bladder, on a ſhelf, in a room of ſo temperate a warmth, that ſcarce any thing ſhall evaporate (tho' it be impoſſible but ſome ſhould) but only amidſt tender mounting ſteams, trickling down again in drops, the leaſt diſtinguiſhable ſeparation, that can be procured. Now, after hitting on the proportion of the veſſel, and the due degree of warmth, there will accordingly be obſerved, ſooner or later, after the precipitation of the very groſs, tartareous, earthy particles from this water, above on the rim of the glaſs, ſmall, white, oblong ſtones, of the length and ſize of oat-grits, adhering ſo firmly to the glaſs, as to remain undiſturbed upon decanting off the urine. The firſt time I came to obſerve them, I could have averred them to be a cryſtallized ſalt; but, upon rinſing them carefully out, they evinced nothing ſaline on the tongue; nor, according to the known quality of ſalt, did they admit a ſolution in the hotteſt water, ſo that they muſt be pure cryſtalline pebbles, oblong and priſmatical, like nitre; figures that the quartzy tacks on *druſe* exhibit moſtly, and of which I procured a drachm from ſix lb. of urine. This ſtoney matter, which may properly be deemed Becker's firſt earth, appears alſo in the actual ſalt of urine, when melted to a glaſs. And here we ſee how excellently, and how far, long digeſtion, nay, even only time and patience, avail in producing forms and effects, generally deemed impoſſible, and ſeldom looked for in elaboratories, except in thoſe of nature; whence ſuch ſtoney matter ſhould be generated in human bodies, is not difficult to be accounted for,

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when we conſider the ſeeds of it may be conveyed along with the water we uſe.

'Tis true, a very ſmall matter of the tender eſſential ſalt of urine is incorporated in theſe ſmall ſtones, as may be eaſily obſerved by its volatility, and extraordinary agreeable ſmell, upon ignition; yet ſo incorporated, nay, fixed as it were, that neither the taſte can perceive, nor hot boiling water extract any of it. Moreover, it is impoſſible to exhibit either a ſaline, or other water, whether natural or artificial, containing earth, that ever yielded the like cryſtals; all the vitriolic, aluminous, nitrous, *&c.* waters, always ſhooting into their own proper ſaline cryſtals, be the time appropriated for that purpoſe never ſo long; yet, with this remarkable difference, that the longer time they take to ſhoot, the cryſtals prove much larger, harder, more durable, and ſo far approach nearer to the nature of ſtone; but, in a pure, inſipid, earthy water, tho' ſtanding never ſo long, no experiment to this purpoſe is extant; and indeed, from waters entirely devoid of ſalt, no ſuch thing is to be expected, as they want the requiſite cement, or interpoſing ſubſtance.

The ſhiver-mines of Ilmenau in Franconia, afford thoſe well known bodies, called *kidneys*, of an oblong oval figure, and encloſed in ſhiver, as in a ſhell. In theſe we often find, together with the figures of fiſh, figured cavities, often containing a clear water, bearing the impreſſions of ears of corn, ſpray of the pine-tree, or rather, a kind of coral, the circumference of which is ſet round with ſmall, tranſparent, white ſtones, like ſugar-candy; and tho' theſe ſtones may be eaſily cruſhed under the teeth, yet, in the fire they loſe nothing of their hardneſs or tranſparency. Now 'tis impoſſible to imagine theſe ſmall ſtones were originally created, the circumſtance of the water contained in the cavities

vities probably ſuggeſting their having ſhot from that water, like a ſalt.

Nor will it ſeem unnatural to view in the ſame light the *druſe*, or thoſe cavities candied over with cryſtals and variegated ſtones, tho' we could not by art imitate their beauty, ſize, and firmneſs, for want of the proper means and opportunities for that purpoſe. It may be preſumed that the earth was, at firſt, a ſoft, yielding, ſpongey body; that, by the gradual ſeparation and evaporation of the ſuperfluous moiſture, it became more and more indurated and exſiccated; that by this means, the earth, in particular the firm rock, came, by violent ſhocks, or earthquakes, to acquire rents and fiſſures; that in theſe, the ſeveral ſorts of waters happened to lodge; that theſe waters contain earth; this earth turns to tranſparent ſtone; all which propoſitions are eaſily deducible from what has been already ſaid: at leaſt, no one, rightly conſidering the proper crude ground-bed of theſe *druſy* ſtones, can find any better method of accounting for their origin: that they ſhould ſpring up from it like a muſhroom, the bare inſpection is ſufficient to diſprove; as no coheſion or connection appears between them, only an external application; and this ſo very evidently, that the *druſy* ſtone lies quite looſe and naked in its neſt or bed, conſequently, without manifeſting any thing like a root, or with its ſtem, which is moſtly a quartz or flint adhering to it, eaſily ſeparable from the crude rock underneath, in which no root is obſerved to run and loſe itſelf: neither can theſe unſaline cryſtals be ſuppoſed to proceed from pure damps or *weatherings*, for the weatherings that produce any thing in fiſſures, move laterally, as may be ſeen in ores on *druſe*; whereas the ſtones in queſtion ſtand up and down, like a ſet of teeth in a jaw-bone; nay,

nay, ſometimes with pieces in them like *water-nuts*, which ſcarce cohere in one ſingle point, often not at all. Upon the whole, all circumſtances agree, that neither an *exhalation* nor *inhalation*, but a cryſtalliſation from waters, like the ſhooting of ſalts or ſugar, is the genuine, if not the only cauſe of mountain-cryſtals, and the like tranſparent, variagated ſtones. I ſhall ſay nothing of their figures, which, like common ſalt, are either cubical; or like nitre, priſmatical; or like *tartarus vitriolatus*, of irregular angles, and unequal ſides, commonly hexagonal: nor mention, that an unſaline cryſtal earth, tho' not in ſuch plenty as a ſaline, is yet as intimately mixed in the water, nay, in the fulleſt degree of clearneſs, paſſes through the cloſeſt ſtrainers; conſequently, the cryſtalliſation of ſalt is here not improperly alledged for a model, or pattern. In ſhort, the *pyrites* is a thing that has grown, ſtill grows at this day, and will continue to grow on *druſe*, ſo long as the interior parts of this maſs of earth are ſubject to thoſe motions and diſſolutions they hitherto have undergone. Here 'tis worth remarking, that the *pyrites* generally poſſeſs the eminences of the *druſe*, and often their outmoſt tacks or teeth, and that only with one of their angles touching in the feweſt points poſſible, and not lying, but ſtanding thereon; ſhewing that they were not there produced, but conveyed thither from ſome other quarter.

I have had many ſamples of *mixt-work*, with rents and breaks in the rock; the former filled up with, and the latter joined together again by *pyrites*. Some *druſe*, or quartz, manifeſt ſuch cracks and apertures, as plainly ſhew they were formerly entire, and afterwards burſt or ſprung aſunder; and in theſe fiſſures the *pyrites* has been found *in-weathered*, or lodged: ſo that I know not whether

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it be ſo very neceſſary to trace ſuch fiſſures as high as the creation, and not rather ſuppoſe them of a much later date. Moreover, I have had pieces very clearly ſhewing that they were broke off, and again joined together by a *pyrites-weathering*, or damp, forming one entire maſs; nay, in part, cruſted over with *pyrites*; but this cannot be reckoned any thing new, or uncommon.

What is worth enquiry is, how *pyrites* can get into cloſe ſolid rock, as a *knauer*; as miners, after maſons and quarry-men, call a ſort of quarry-ſtone, found with us, and generally elſewhere, directly beneath the under-turf earth; conſiſting of very ſmall, nay, ſcarce diſtinguiſhable ſeams, and two ſorts of ſtone; one, a grey, ſparkling, ſcaly ſort, or a *glimmer*; the other, a white, quartzy ſort, conſtantly interchanged with the former, and both cloſely joined together.

In this *knauer* ſmall eyes of *pyrites* lie, and that on the fineſt fiſſures, but not diſcoverable before the ſtone is parted aſunder, and then moſt certainly, the *pyrites* often appearing ruſty; conſequently, a *weathering*, or a *watering* producible of ruſt, muſt have found acceſs thither. Theſe eyes are alſo here and there ſingly interſperſed in the moſt entire and firm rock, without the leaſt ſigns of any deſtruction or diſſolution. Whether the firſt be ſhoots or capillary veins from larger branches, I ſhall not pretend to determine, but the ſecond are ſomething peculiar: they cannot be conſidered as ſmall *ſhoads*, as the *knauer* itſelf is not ſuch, but a rocky, wild ſtone, conſtituting an original part of the creation; conſequently, ſuch eyes muſt have been produced in its ſoft, juicy, and yielding ſtate, before the matrix was become perfectly hard, and unfitted for conception, in which caſe, the impregnating damps and mineral juices could have no acceſs.

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We are next to examine thoſe periwinkle and muſcle ſhells, either quite penetrated, or cruſted over by the *pyrites*; and ſome of theſe ſhells have their whole cavity lined therewith, as the *belemnites*; others, together with the *pyrites*, hold a ſelenitical matter, or gypſum-ſtone; again, in others, the ſhell is entirely *pyrites*; again, the *pyrites* is externally *weathered* on the periwinkle or muſcle figure, which is commonly a marl, or gypſum-ſtone, ſometimes at one, ſometimes at the other end, and ſometimes all over it; and, which is the rareſt caſe, the ſhell ſtill remaining, the *pyrites* lies immediately either on, under, or between the ſhell. Now though periwinkles and muſcles are in ſuch quantities in nature, the number thus petrified is hitherto found inconſiderable; but the ſamples I have either in my own poſſeſſion, or have ſeen, or been told of, are moſtly *cornua ammonis*, *tellinæ*, *chamæ*, *aſtroitæ*, *belemnitæ*, *turbines*, *pectinitæ*, *fungitæ*, *alveolus*, *Luidii*, &c. Though 'tis not to be doubted, but time may diſcover more ſorts; nay, that the ſame may be preſumed of all ſuch as lie in earths, where nature finds materials, opportunity, juices, free acceſs, and the like circumſtances, as grounds and foundations for a *pyritification*; for, both muſcle and periwinkle *works* are all, in the ground of their earthy mixtion, one and the ſame, namely, already ſuch in nature as that, among all the parts of animals, nothing comes nearer to the ſtones of the mineral kingdom, eſpecially the calcarious ſort; conſequently that they are fitted, almoſt in their native ſtate, or at leaſt without any peculiar tedious preparation, barely by means of a ſlender exſiccation, both for a proper petrification, and the conception of ore, is not repugnant to my hypotheſis. And thus it depends on the abovementioned circumſtances, that ſuch ſhells are, at ſome times, now found changed;

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at others, not at all; alſo, that the ſhells either continue to ſubſiſt, or are entirely conſumed; and laſtly, that generally they have no *pyrites* in or about them: as, among others, we have an inſtance in the ſand-ſtone, wherein I have, with difficulty, found ſuch *pyritified*. From a due conſideration of all the circumſtances evident in this ſubterraneous muſcle hiſtory, we cannot ſuppoſe theſe bodies to be the effects of a *luſus naturæ*, or even to be of a ſubterraneous origination.

And ſhould it be objected to my making the productions, namely, the volatile ſalts and fœtid oils, procurable in the fire from ſuch foſſil, figured wood, muſcles, and bones, certain indications of their vegetable and animal original, that theſe ſalts and oils are already contained in the earth, in particular, that common ſalt is extremely fitted for volatilization; that, probably, the ſal-ammoniac at Puzzuolo in Italy, and the like places, where the bituminous ſea-water, or even ſal-gem, is, together with *pyrites* and ſtone-coal, made to act in a due manner in the bowels of vulcano's; and the petrols, which ſtand proximately allied to amber and ſtone-coal, greatly reſemble our oils, burnt out of the fatty, reſinous parts of plants; that from *aſphaltum*, black and yellow amber, from aluminous, ſtone-coaly, black, fatty, ſhivery minerals, not only ſuch oils, but, in part, alſo volatile ſalts may be prepared; yet it does not therefore follow, that the origin of theſe things in queſtion, though they manifeſt themſelves in, is immediately from the mineral kingdom. In a mediate ſenſe indeed, according to which every thing in nature is in a conſtant rotation and flux, we muſt allow, not theſe matters only, but alſo the entire vegetable and animal kingdoms, to be derived from the earth, and thence from the widely extended mineral kingdom.

Now,

Now in and upon theſe matters, dug out of the earth, all kinds of *pyrites* are often very evidently ſeen; tho' not ſo frequently on bones, at leaſt ſo far as my experience reaches; a thing not to be wondered at, ſeeing they are not ſo common as periwinkle and muſcle ſhells are; the ſame alſo holds good of wood, which is not ſo well adapted for mineraliſation. To conclude the buſineſs of the generation of the *pyrites*, and of ores in general: they are not all of them to be aſcribed to the firſt day of the creation; conſequently, nothing hinders their being ſtill produced at this day.

I have ſtill to add, that the generation of ores appears in ſome meaſure to me in the ſame light, as that of vegetables and animals. In ſome meaſure, I ſay: For (1.) ores ſhed no formal ſeeds, from which, with the concurrence of a proper matrix, ore is again produced. (2.) Ores, according to their internal mixtion, have no fixed period of duration, but remain for ever unchanged, if not expoſed to external violence, partly, on account of their peculiar unchangeable manner of mixtion; partly, their bedding, from which the air and warmth thoſe grand inſtruments of deſtruction are excluded. Whereas vegetables and animals have their deſtined periods, tho' ſtretched out ever ſo long, from the tenderneſs of their mixtion and texture: but ſo far only I make the reſemblance to hold, as in the vegetable and mineral kingdoms, ſome die, and others again revive.

CHAP.

CHAP. VI.

Of the IRON in the PYRITES.

IN the foregoing chapter having treated not ſo much of the material origination, as rather, if not principally, of the time of the production, and conſequently of the creation and generation of the *pyrites*, I ſhould now immediately proceed to its material principles: but this, at preſent, is neither adviſeable nor poſſible, tho' a method of writing that moſt are fond of: ſeeing we muſt firſt conſider *pyrites*, as analyſed into its proximate parts, and thus mediately proceed to its principles: and we can as little pretend to begin our reſearch as deſcription there, where nature has begun her work; there being difficulty enough to diſcover ſuch principles, as I will not ſay, ought to be made objects of our ſenſes, a thing neither poſſible nor reaſonable to acquire, but by probable concluſions only, fairly flowing from obſervations.

There is the ſame difference between the conſtituent parts and the original principles of a natural body, as between proximate and remote; *pyritæ* are derived from water and earth, as their principles, or remote parts; but conſiſt of the following *mixts*; viz. the fat earth, or ſulphur; the mercurial earth, or arſenic; the metallic earth, or *iron*, as their proximate parts. Some inſtances there are, in which *analyſis* ſtands verified by *Syntheſis*; others, in which it does not. Cinnabar not only conſiſts of quickſilver, as its ſeparation plainly ſhews, but may again be formed from

ſulphur and quickſilver, and that moſt eaſily and conſtantly; and there may ſpeedily, though not conſtantly, be prepared a formal antimony from regulus and ſulphur: But in compounding ſulphur and iron, the parts into which a pure *iron-pyrites* is evidently reſoluble, it does not ſucceed. The reaſon of this difference is, in the firſt place, to be ſought for in the metallic earth of *iron*, which is highly coarſe and fixed, nay the crudeſt of all, and proximately derived from the univerſal unprepared earth itſelf, and conſequently not ſo combinable with the tender, volatile, elaborated, mercurial, reguline earths. 2dly, The ſulphur, which is ſomething highly tender, volatile, and diſſipable, flies off and is deſtroyed, before ever the *iron* can, by ignition, be brought to conception; or the *iron* comes to be unfit for the purpoſe, by loſing its metallic form, and turning to a ruſt, in which the ſulphur cannot find a due ingreſs to coaleſce with it. And hence it is, the ſulphur is ſo ſuperficially combined with the *iron* in the pure *iron-pyrites*, that without any force or violence, ſuch as cinnabar and antimony require to ſeparate out of it, barely by the external heat, nay, by the bare acceſs of the air, without fire at all, it may be made to operate on its accompanying *iron*: which is the formal reaſon of the crumbling and vitrioliſation of the *pyrites*. It, however, from hence and other inſtances appears, that the rule, implying the neceſſity of proving *analyſis* by *ſyntheſis*, among ores and decompounds, ſuch as ores commonly are, ought not to be looked upon as univerſal; ſome bodies evidently bearing *analyſis*, but with difficulty, if at all, *ſyntheſis*; for inſtance, the *pyrites*; others again eaſily bearing compoſition, but difficultly, or not at all, reſolution; as the neutral ſalts.

We

We ſhall, in the firſt place, enquire into the conſtituent parts, then into the principles of the *pyrites:* the former we ſhall conſider in this and the following chapters; the latter, namely the principles, in a chapter apart.

In order to treat with propriety of the conſtituent parts of the *pyrites*, we muſt premiſe its diviſion into *ſulphur* and *arſenic-pyrites*. By the former I underſtand not only that ſort which yields ſulphur and pure *iron*, with little or no copper or arſenic, conſequently little or no ſandarach: but alſo *copper-pyrites*, nay, rich copper-ores; by the latter, that white ſort, which contains pure arſenic with but very little *iron*, copper, or other metal, and with little or no ſulphur; the arſenic being in form either of a grey meal, or a ſooty arſenical ſublimate or *fly-ſtone*, and giving, by means of a proper addition of ſulphur, ſandarach; this kind of *pyrites* is at Friberg called *miſspickel*, but in the Obergeburge, *poiſon-pyrites*.

In ſhort, the former are either more, or entirely ſulphureous; the latter more or entirely arſenical. Now in the ſulphureous, the *iron* is the principal and largeſt part, and of which they all indeed conſiſt; copper holds the ſecond rank, which in ſome is none at all, in others in a ſmall, in others again in a very rich proportion; ſulphur, the third, and which like the *iron*, is in all the kinds of the *pyrites*; arſenic, the fourth, of which in many there is none, in ſome only a very ſmall proportion, in others a conſiderable one, bewraying itſelf either in the *ſulphur-ſlags*, or in the ſandarach; but contained in no one *pyrites*, where *iron* and ſulphur conſtitute the capital parts, ſo largely, as without the addition of *miſspickel* to the

ſulphur ſlags, to be worked for ſandarach, ſo as to quit the trouble. In the arſenical ſort, a ſtoney *iron-earth* is the principal and largeſt portion; and what is called the *fly-ſtone*, the ſecond and laſt; with the obſervation, that whereas the ſulphur in the firſt ſort makes a fourth in reſpect of the *iron*; here at Friberg the arſenic in the *miſſpickel* commonly makes a third; and at the Obergeburge, often a full half, in reſpect of the remaining irony, quartzy matter. Nay, the abovementioned black, arſenical, foſſile matter, otherwiſe to be found near *red-goldiſh* ore, but particularly pure, without the like accompanying rich ſilver-vein, in a mine near Schwartzenberg, and there alſo called *poiſon-pyrites*, alſo *teſtaceous cobald*, contains neither *iron*, nor any other earth, but in the fire ſublimes in its entire ſubſtance, and thus proves a pure arſenic, or foſſile *fly-ſtone*. But here the name is miſapplied, if we abide by the definition of *pyrites*, namely, its being an ore, conſiſting either in a ſulphurated or arſenicated metallic earth; whereas this, on the contrary, can ſhew nothing, either of a metallic, or other earth. On theſe ſeveral conſtituent parts of the *pyrites*, I ſhall take notice of what I take to be ſubſervient to my principal view.

To begin with *iron*, as the principal conſtituent part of the *pyrites*. In general, it deſerves to be remarked of that metal, that it conſiſts of a metallic earth, proximately ariſing, above all others, from the crude, undetermined earth itſelf; as, among other things, appears from the following obſervations. (1.) In moiſture, particularly in the moiſt earth, it very eaſily turns to a ruſt, conſequently to an earth; which can be ſaid of no other metal, but lead and copper, which change, the one

one to ceruſs, the other to verdigreaſe, tho' neither ſo quickly, nor in ſuch quantities. Nay, ſuch an earth, eſpecially that from *iron-ore*, ſhall, according to Becher's peculiar experience, ſo very much degenerate, and turn to a mud and loam, as to loſe all metalleity *. (2.) *Iron* alſo, by fire, turns ſooner to a ruſt and earth, than copper, lead, tin, and quickſilver, which ſubſiſt longer: and this ruſty *iron-earth*, particularly that procured by means of the air or water, and which, in various views, is now called *ſinter*, now *ochre*, now *yellow*, ſo nearly reſembles, in tenderneſs and fattineſs, an univerſal, yellow-brown, marl-earth, as to be undiſtinguiſhable from it. (3.) Amongſt ores, iron in the *pyrites*, next to cinnabar and antimony, holds the moſt ſulphur, but parts with it much eaſier than they, even ſpontaneouſly; and though in the *mercurification* and *regulation* of cinnabar and antimony, it muſt ſeparate the ſulphur, yet it takes a little to itſelf. Copper retains ſulphur more obſtinately, fluxing and caking together, rather than parting aſunder. The lead in *lead-glitter*, or galena, will neither ſo eaſily ſeparate from its ſulphur, but rather vitrify into a cake; though here, as for antimony, *iron* is uſed with advantage, for parting the ſilver: regulus and quickſilver go forth with the ſulphur, rather than part with one another. In a word, *iron* has too coarſe, and ſulphur too ſubtile an earth, to be able, though ſtrongly operating on each other, to mix and combine together laſtingly. (4.) *Iron*, by cementation, takes a much leſs quantity of ſulphur than copper does; for, equal parts of ſulphur being conveyed on glowing *iron*, and glowing copper, the former comes to have about an eighth, the latter a full third part combined to it. (5.) *Iron*, as well as ſome other metals, refuſes to amalgamate with

* Phyſ. Subterr. p 595.

quickſilver; a circumſtance to be aſcribed to its earthineſs, as to a crude, unprepared metalleity. In the next degree to iron ſtands copper, which alſo reſiſts quickſilver, as we ſhall afterwards perceive. (6.) *Iron* is a metal generable not only from all ſorts of crude, particularly loamy, claiey, marly, fatty earths, as Becher's famous experiment ſhews, but alſo gives itſelf forth, both by nature and art, from vegetable and animal earths, and thus from earths already derived from the mineral kingdom; as *there*, M. Lemery ſhews *, by the magnet, from wood reduced to aſhes; M. Seipius †, from a piece of wood found reduced to *iron* in a certain ſpring: and I myſelf, in my ſmall collection, can ſhew from the like peculiar pieces from Bohemia; and M. Liebknecht §, from the like ſamples: and *here*, from the bones of men turned to *iron* ‖. Now I would gladly ſee half theſe obſervations, nay, Becher's ſingle experiment only, as eaſily applicable to other metals. So greatly does *iron* differ from all its ſiſter metals, as to claim the right of primogeniture! Only we muſt guard againſt running into the alchemiſtical conceit of the other metals being derived from *iron*. And here we may, with Stahl **, juſtly complain of Becher's not having diſtinctly enough communicated Paracelſus's experiment on the tranſmutation of *iron* into lead.

Now, ſince a crude, loamy, and ſlimy earth may ſo eaſily become metallic, particularly *irony*, 'tis no wonder we ſhould look for an *iron ore* in claiey, luty, ſhivery, talcky, loamy, *&c.* beds: and

* Hiſt. de l'acad, &c. Can. 1706
† Vom Pyrmonter Sauer brunen. p. 51.
§ De ligni in mineram ferri facta metamorphoſi.
‖ Acta Erudit. An. 1682.
** Spec. Bech. p. 159.

and ſince the *pyrites* is there ſo often to be met with; beſides, no other mineral ſo very common and plentiful in all ſorts of ſtone and earth; and *iron*, ſo univerſally preſent in all *pyrites*, nay, in many other ores, 'tis more ſtill to be wondered that the ancients ſhould have overlooked it ſo much, and turned their thoughts on copper only, to the quite diſregarding the iron-yield of the *pyrites*; in which reſpect Agricola himſelf ſeems alſo to be at a loſs. And, ſo far as I can learn, Dr. Martin Liſter *, was the firſt, or among the firſt, who ſeems to be aware of *iron* being the capital conſtituent part of the *pyrites*, or the firſt who clearly expreſſed himſelf in this matter: Pyrites *purus putus ferri metallum eſt*, the pyrites *conſiſts entirely of* iron; though (when in another place he ſays, *unus Angliæ* pyrites, *purum putum metallum eſt*, *one ſort of* pyrites *conſiſts entirely of iron*) I much doubt, whether he was quite ſo ſure of the truth of his former enunciation, and whether he knew to give it its full latitude, and true extent. Among the Germans, together with the celebrated Dr. Hoffman at Hall, the famous Dr. Berger claims the honour of the diſcovery, as he has ſolidly ſhewn in his excellent treatiſe on the Carlſtad baths †. As to myſelf, I had ſome difficulty, at firſt, to admit of the vaſt extent and ſpread aſſigned the *iron* in all ſorts of *pyrites*; nor were my doubts removed by conſulting either ſmelters, or the writers on natural hiſtory, but by a careful examination of the ſeveral ſorts of *pyritæ* themſelves, and that with no ſmall pains and expence; by that means only I came to be fully convinced of the truth of what Liſter and Berger had writ to that purpoſe. What made me call in queſtion the aſſertion of theſe great men was,

* De Fontibus Medicatis Angliæ, p. 43. Ib. p. 19.
† Bergeri Commentatio de thermis Carolinis.

that thoſe *pyrites*, which, with us at Friberg, give only a few pounds of copper, are no longer called *pyrites* abſolutely, but *copper-pyrites*; and that thoſe containing ten, twenty, thirty, and more pounds of that metal the quintal, ceaſe to be called *pyrites*, and take the appellation of *copper-ores*; that, however, many, nay, moſt *pyrites*, with us at Friberg, are not purely martial, having ſome ſmall matter of copper in them: but, in fact, I ſoon diſcovered the above aſſertion to have all the juſtneſs and ſolidity that any other propoſition in mineralogy could poſſibly claim: and my experience in *pyrites* has been ſo extenſive, that, without heſitation or reſerve, I may aver, all the ſorts of them, the *white*, the *yellowiſh* and *yellow*, in regard of metal-yield, to conſiſt either entirely of, or to hold *iron* in equal quantity; or ſhould the *iron* be exceeded by the copper, yet ſtill to maintain its rank as a conſtituent part thereof.

Therefore I aſſert more than what, I think, the above authors have done, namely, that *iron* conſtitutes the ground-earth of all ſorts of *pyrites*; a truth to be met with in no other author that I am acquainted with, though no great art be requiſite for making the diſcovery, being what is eaſily found by only the magnet; a circumſtance that ſeems to do no great honour to our care and attention, as thus the moſt common and obvious things often eſcape our knowledge; not to mention the ſubtilities and empty ſpeculations of philoſophers, who, overlooking the information of the ſenſes, rather confound than clear up matters.

The Heſſian *pyrites* from Almerode, called *terra martis Haſſiaca*, and *Solaris*, but from what hea-

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ven I know not; the round *pyrites* of Alt-fattel, not far from Egra in Bohemia; the *pyrites* from the Schloſsberg of Toplitz; alſo that round *pyrites*, eaſily crumbling or falling to pieces in the air; and the *periwinkle* and *muſcle pyrites*, are, all of them, a pure *iron-pyrites*, without any the leaſt copper; alſo excel all others in the fineneſs and purity of their ſulphur. In a word, the *pyrites* of Acidulæ, Thermæ, and other medicinal ſprings, nay, all *pyritæ* in general, that ever came to my hands, and were ever found at mines, in fiſſures and veins; or that only *break* in clay, loam, ſand, ſhiver, lime, and other ſtone-quarries, are, with reſpect to the metal, almoſt all pure iron, only that they are often intermixed with a little copper. In Miſnia there is neither mine, nor vein, of what kind ſoever, coarſe or noble, at what depth ſoever, in what direction or point ſoever of the compaſs; no ore or ſtone, of what nature or name ſoever, where the *pyrites* does not moſtly and principally conſiſt of *iron*, the copper adhering to it being ſcarce viſible, much leſs educible. All the copper-ores of the following Miſnian mines, *viz.* the Halſebrucke, Kuhſchaft, Hohenbircke, Kroner, Braunſdorff, Kayſer-Henrich, Zwolf Schluſſeln, *&c.* are never without copper and *iron*; nay, often contain more of the latter than of the former.

One proof of this propoſition, namely, that *iron* is the ground-earth of all ſorts of *pyrites* the magnet ſupplies us with, and ſo much the more infallible, is this proof, as we know of no other body thus acted on by the magnet; though its force may be ſpoiled, or impeded, upon over-burning, eſpecially in an open fire, and reducing the *pyrites* to a brown-red, ruſty earth: but this earth may

again

again be made to anſwer the magnet, if, by a due ſmelting, its metallic fattineſs be again procured to it. All *pyrites*, without exception, deſulphurated in cloſe veſſels, anſwer the magnet equally with ſmelted iron, and a genuine *iron-ſtone*. Even the *pyrites*, that contains copper in no great quantity, is acted on by the magnet; that holding much as ten, twenty, thirty, and more pounds the quintal, not ſo ſtrongly, but more or leſs in proportion to the copper it holds; but the copper predominating in a greater proportion, the virtue of the magnet proves more weak and effete, or has no effect at all. The magnet alſo exerts ſome efficacy on the *miſſpickel* of Friberg, and the *poiſon-pyrites* of the Obergeburge.

In order to know what ſort, and how much of other metals the magnet can bear, ſo as to continue to exert its virtue; I, by it, after deſulphuration, examined different *pyrites-copper-ores*, and plainly found it attracted them all, though not within the ſame ſphere, nor with the ſame briſkneſs of activity, as it does the pure *iron*, or poor copper *pyrites*; but by it I could not diſcover the exact proportion of *iron* and copper in each, and, conſequently, how much copper the magnet can bear in the *iron*, without loſing its virtue thereon; only I obſerved a greater efficacy exerted on one ſort, as the *pyrites* of Ilmenau and Sweden, than on thoſe from Lorentz-vein, near the Halſebrucke; thoſe from the Kuhſchaft, Kroner, Kayſer Henrich, Goſlar, *&c.* in general; but then 'tis not poſſible, in an intelligible manner, to ſpecify the particular degree of attraction. Again, I am not ſure, whether the *pyritæ*, which here, in reſpect of the magnetic virtue, are to be compared together, have always gone through one and the ſame degree

degree of fire. For, according as a copper-ore happens to be burnt too little, or too much, the magnet manifeſts a greater or leſs degree of briſkneſs on it: and ſhould I attempt the making a proof or two only, it would be impoſſible ſo exactly, in the other proofs, to hit again on the due length of time, and the proper degree of fire: or, ſhould I work ſeveral proofs at once, as, for that end I have conſtructed my reverberating furnace for deſulphuration, one and the ſame degree of fire could not poſſibly be applied to each apart: not to mention, that of many ores I have only employed ſmall parcels, being only provided with ſuch; whence 'tis eaſy to judge, a ſmall parcel may be ſooner fitted for the magnet than a larger: and laſtly, 'tis probable, *pyrites-copper-ores* do, together with the two capital metallic earths, contain alſo a crude, unmetallic earth, and that in various proportion, and which is neither to be weighed nor meaſured. So that, beſides the copper, there is ſomething elſe in the *pyrites*, that hinders and weakens the effects of the magnet.

But, ſtill more certainly to diſcover the proportion of copper the magnet can bear in the *iron*, I melted both theſe metals together in different proportions; as for inſtance, filed *iron*, and filed copper, in various layers, committed to a crucible, with a flux conſiſting of two parts of the black flux, and glaſs, and one of borax and ſalt of tartar, to between one and ½ and two parts of metal, and found the magnet could bear in the *iron* half the copper; nay, I doubt not, a greater proportion, which I cannot at preſent aſcertain, as ſeveral proofs miſcarried with me. Being engaged in theſe experiments, I was willing to know what, and how much of other metals the magnet could ſuffer in *iron*, and the reſult was as follows.

(1.) *Iron*

(1.) *Iron* doſed with the above ſalt and glaſs, even in the briſkeſt fire of a wind-furnace, not to be brought to flux without calcination and reduction. (2.) *Iron* making a black ſlag. (3.) *Iron* refuſing melting with lead, and always ſwimming a-top, unleſs previouſly diveſted of its metalleity, and reduced to an earth; whereas, otherwiſe, in its metallic form, intimately entering into all metals and ſemi-metals. (4.) *Iron* burning away ſooner than copper, becauſe more difficultly ſmelting. (5.) *Iron*, to be acted on by the magnet, bearing as much gold as copper. (6.) Alſo as much ſilver. (7.) *Iron* entering tin, forming therewith a regulus, on which the magnet ſtrongly acts. (8.) With zink forming a malleable regulus, like ſilver, yet hard, and not backward to the magnet. (9.) *Iron* going into biſmuth in ſuch ſort, that tho' the brittle regulus thence ariſing, be conſiderably impregnated with, nay, conſiſt of above ¾ biſmuth, yet, notwithſtanding, anſwering the magnet. (10.) *Iron* melted along with braſs, continuing ſtill ſubject to the magnetic virtue, where the calamy is ſtill obſervable from the yellow caſt of ſuch *iron*. (11.) The magnet alſo bearing regulus of arſenic, prepared by means of *iron*. (12.) Bearing *fly-ſtone*, ſublimed from *miſpickel*, or poiſon-*pyrites*; alſo the being ſmelted with *iron*. (13.) But not at all bearing the regulus of antimony in the *iron*, though I have made the trial in various ways; neither the *lapis de tribus*, though metalliſing with *iron*; a circumſtance I as much admire, as others may be apt to diſbelieve it. I ſhall further add, from my experience, that from *iron* and tin, a quintal of each, I have procured one quintal and ½ of regulus; from four quintals of biſmuth, and one of *iron*, four quintals and ¼ of regulus; from

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—— quintals of *iron* and antimony, four quintals of martial regulus of antimony.

A ſecond proof for the univerſality of *iron* in *pyrites*, we have from antimony, ſeeing on the *pyrites* the ſulphur of the antimony is equally conſumed, as on forged *iron*; depoſiting, eſpecially with the addition of proper ſalts, the regulus, ſo far forth as the pulverized ſtate, to which the *pyrites-iron* muſt, by the deſulphuration, be reduced, will permit: ſo that the very few *pyritæ*, wherein the copper entirely predominates, cannot reaſonably be ſuppoſed to affect our proof, as the exiſtence of ſuch an *iron* metal-earth ſeldom can be denied.

A third proof we have from the vitrioliſation of *pyrites*; all *pyrites* giving forth a vitriol, as they all hold a ſulphur, excepting the *miſpickel*, when pure and unmixed with other *pyrites*. All ſorts of vitriol, whether native or factitious, are either purely martial, purely coppery, or conſiſting of both: the firſt is of a ſea-green caſt, and ſweetiſh taſte; the ſecond blue, and taſting ſharp and nauſeous; the third, wherein the martial predominates, may conceal its coppery nauſeous admixture from the ſight, though not from the taſte. In ſhort, all vitriols conſiſt (1.) of the ſtrongeſt mineral acid, which comes either from ſulphur, or the air: (2.) of a metallic earth, which is always either *iron* or *copper*, or both together, though in different proportions; whence all the vitriols, as they are called, from ſilver, lead, *&c.* made by means of aqua fortis, vinegar, *&c.* cannot be claſſed with the abovementioned. As to pure coppery vitriol, it will be a hard matter to find any ſuch; for though the *cement waters*, as they are called, or, properly, the *copper-waters* of Hungary,

gary, and other parts, do, by throwing in *iron*, let fall the fineſt ſort of copper, it does not follow that they are purely coppery, ſeeing there are few pure *copper-pyrites* in nature: and ſuch *pyrites* as naturally turn to vitriol, cannot do ſo without ſome admixture of iron; but a pure copper-vitriol muſt be ſolely prepared from fine, ſmelted copper; or otherwiſe, by art, and with the greateſt attention ſeparated from mixt vitriol. The third ſort is the moſt common and univerſal at mines and huts; and, whether native or factitious, it will, upon proper trial, particularly upon a due ſeparation, be found to be mixed. The firſt ſort is, nevertheleſs, not ſo very rare, that we need go in queſt of it as far as Almerode in Heſſe. But tho' our ſulphur and vitriol *pyrites*, as they are called, generally contain ſome copper, yet, by a due evaporation, and cryſtalliſation, of ſuch vitriolic admixture, a conſiderable quantity of pure *iron* vitriol may be procured.

(4.) It is alſo obſervable, that the regulus procured in ſmelting for copper-ores, and called *black copper*, has that black colour chiefly, if not always, from the *iron* ſuch ores happen to contain: moreover, there is no one ſort of copper-ore, that remains untouched by the magnet.

(5.) I might here alſo alledge thoſe ſcoriæ, which, in copper-ore proofs for ſilver, always ariſe dark and black; whereas, doubtleſs, had there been no *iron*, the colour would prove of a liver, a brown-red, even to a high-red caſt, the proper colour of copper: for though lead, without which no *incoction*, or *ſcorification*, can poſſibly be made, ſhould happen to mix with it, yet it could not entirely deſtroy the original colour of the copper;

as

as little as it does the black caſt of the ſcoriæ of *iron-pyrites*, though it bring them ſomewhat nearer to a brown. I ſhall leave to further reflection the vitrification I performed, without *additions*, in a glaſs furnace; where, both from copper-ore, the common *pyrites*, pure *ſulphur-pyrites*, and the arſenical, as the *miſpickel*, and mock-lead, I uſually procured a black, dark glaſs.

CHAP.

CHAP. VII.

Of the COPPER in the PYRITES.

NEXT to the iron, the principal metallic earth to be looked for, and met with in the *pyrites*, is *copper*. *Pyrites* is never without iron, often without *copper*, which, next to iron, *pyrites* moſt affects, and which, of all other metals, is the neareſt allied to iron; as may appear from the following remarks. (1.) I own there is no experiment extant to aſcertain the tranſmutation of iron into *copper*, though a great deal has been ſaid to that purpoſe; the error having, at leaſt, ariſen from the vitriolic waters of Hungary, wherein a precipitation, rather than a tranſmutation of *copper* happens by means of iron. As Lohneiſs * mentions the like to happen at the Rammelſberg; and the late M. Heineman, inſpector at Bottendorf, made an ingenious imitation to that purpoſe; and I myſelf, but lately, to my great ſatisfaction, in the tin *ſtock-work* at Altenberg. As to the arſenical *pyrites* of Sweden, from Gothe-gruffwan in Weſtmanland, which, after ſome years expoſure in the air, is ſaid to turn entirely to a *copper*, this proves to be either a miſtake, or a bare hear-ſay, without any foundation †; yet, I imagine that a tranſmutation among imperfect metals, ſuppoſing ſuch a thing poſſible, ſhould ſooneſt of all happen between iron and *copper*. (2.) *Copper*, next to iron, is

* Berg-buch, p 332. Toll. Epiſt. Itin. V. p. 192. Wedel. in Ephim N. C. Dec. I. Ann. VI. VII. 1673. 1676.

† Leopoldi Epiſt. de Itin. Suecico. p. 82.

is the moſt univerſal metal in nature, there being ſcarce a vein, whether of lead, tin, or even of the richer ſorts, without it; though there are veins of pure copper-ore, without any admixture. (3.) Along with the ſulphur in the *pyrites*, *copper* exhibits much ſuch a mixture as iron does, only that in one the colour is ſomewhat more yellowiſh, in the other more pale; and in this reſemblance other ores do not equal the *pyrites*, though they may one another: for inſtance; ſulphur with lead, ſulphur with regulus, alſo, by means of art, ſulphur with tin, have a conſiderable reſemblance among themſelves. (4.) *Copper*, 'tis true, does not emit its ſulphur ſo readily from its ore as iron does, but rather runs, and cakes together; and therefore will not bear any violence of fire, but only ſhould be treated with a ſoft degree of roaſting: and when, by the interpoſition of quartzy, mock-leady, and the like ſtubborn ſorts of earth, their running together, or caking, is prevented, the ſulphur alſo the more readily ſeparates. (5.) Both of them, in one and the ſame manner, receive again the ſulphur by cementation; only that the *copper* is ſomewhat more penetrated by it, alſo retains more of it, and for a longer time. For the reſt, both of them, along with ſulphur, form a ruſty, ſooty maſs; whereas the white metals, and the ſemi-metals, uſually, by its means, acquire a *glittery*, antimonial, and thus a more *ory* form. (6.) All imperfect metals, without any one *addition*, may be made to burn away, or rather loſe their metalleity, and turn to an earth; yet none ſo eaſily as *iron* and *copper*. Stahl * ſuppoſes this to happen ſooner to the latter than to the former, but, in my opinion, equally to both; though, from my proofs, which are difficult to be made

* Specim. Bech. p. 298.

accurately, I cannot ſupport the contrary; only ſo far I obſerve, that both metals, if not ſuddenly committed to a very briſk degree of fire, throw off ſcales, which hinder the ſmelting; nor do they recover their metalleity even by the ſtrongeſt pitch of fire, without *additions*, but turn to a ſcoria or glaſs: which remark, in regard to a ſudden briſk fire, may be alſo made, with reſpect to the other metals, particularly lead and tin. (7.) Iron and *copper* are the only two metals, which change to a proper vitriol, a thing not to be affirmed of any other. Whence (8.) it appears, that theſe metals are of an equal fitneſs and texture to receive the mineral acid, whether from ſulphur or the air; tho' indeed with ſome inequality in this receptibility, which is greater in iron than in *copper*; whence the latter appears to be of a cloſer texture than the former; particularly ſuch a body, as returns not ſo readily to its univerſal *terreity*, but is arrived to a more heightened degree of *metalleity*. Nay, (9.) they both lodge well together in a vitriol; and tho' at laſt by a careful evaporation, like all other ſaturated ſalts, they may be conſiderably ſeparated from each other, yet the *copper* with difficulty parts from the iron, after having once been in contact with it. (10.) Next to iron, *copper* is of all metals the moſt difficult to flux in the fire. (11.) *Copper* is alſo the hardeſt metal: whence, among the ancients, in defect of iron, it was uſed for making ſwords and ſcythes; as in the cabinet at Stockholm a ſword of that metal is ſtill to be ſeen, and the like uſually to be met with in ancient graves*. (12.) In both, preferably to the other metals, gold finds a lodgment and an aptitude for generation; yet more ſo in *copper* than in iron. (13.)

Copper,

* Elvii & Benzellii Schediaſma de re metallica Sueco-Gothorum, p. 14.

Copper, next to iron, amalgamates with mercury with the greateſt difficulty; whereas gold and ſilver amalgamate with eaſe; alſo lead, tin, and zink moſt readily. (14.) The magnet chiefly and in greateſt quantity bears *copper* in iron.

Whence, *a priori*, 'tis eaſy to ſee, what probability there is for *copper* to lodge along with iron in *pyrites*: and, *a poſteriori*, or from examining the *pyrites* itſelf, what juſt foundation there is for that probability. But, as *copper* is not common to all the ſorts of the *pyrites*, ſome containing pure iron only; and conſequently, as the *pyrites* may ſubſiſt without *copper*, ſo *copper* muſt not be conſidered in the ſame light as iron: namely, as an eſſential part of the *pyrites*. But in regard the incidental exiſtence of *copper* therein extends ſo very widely, that (1.) very few *pyrites* are without it; (2.) many *copper-pyrites* have a large *copper-yield*; nay, ſome of them, almoſt to a half; ſo, next to iron, this metal deſerves our greateſt attention. Though I would not diſpute the excluding ſuch *copper ores*, as come very high in *yield*, from the claſs of *pyrites* in general, and the putting them in a peculiar claſs by themſelves; and then conſidering the *copper* therein, not as ſomething incidental, but as a neceſſary part of that ore. Only we muſt not, with the Ancients, run to the other extream; namely, that of neither regarding, nor looking for any other thing in the *pyrites* but *copper*, as if they never contained any iron.

Hence it has happened, that vitriols have no one name aſſigned them, denoting their iron; being indiſcriminately called *chalcanthum*, *chalcitis*, *cuperoſa*, or *cupriroſa*, &c. And this has ſo far prevailed, that not only in Greece and Italy, but even in Germany it-

ſelf, all ſorts of vitriol, even that principally from iron, have to this day no other appellation than that of *copper-water*; the iron being conſidered as ſomething incidental, even by modern mineraliſts.

Copper, however, has a very extenſive ſpread in the *pyrites*; in regard to place, *yield*, and alſo *mightineſs*, as miners uſually ſpeak, with reſpect to the breadth and thickneſs of their veins. As to place, there is ſcarce a mine, without ſome appearance of *copper-ore*. 'Tis found in all ſorts of earth and ſtone; in ſhiver, lime-ſtone, quartz, ſpad, *kneiſs*, and *gemſs*: though it generally appears, that the *pyrites* in clays, lutes, and lime-ſtone, are for the moſt part principally *irony*; and often pure and unmixed; whereas *copper-ores*, either poor or rich, muſt be ſought for in quartzy, ſpathy, ſhivery, and the like ſtone. *Copper-pyrites*, or ore, *breaks* at different depths; in ſome places, in *day veins*, as has been ſaid above, almoſt beneath the under-turf-earth; though rarely, and as may be eaſily imagined, thinly ſown, and not ſo *mighty* as in the *deeps*; in other places, and more frequently, in the *depth*; of which the famous mines at *Fahlun* in Sweden are pregnant inſtances.

Here I have often put the queſtion to myſelf; whether the *pyrites* does, with the depth, decreaſe in iron, and increaſe in *copper* yield; namely, with this view; whether the common *pyrites*, employed in making ſulphur and vitriol, and in the operation of *crude-ſmelting*, and in metal pure iron almoſt decreaſes with the depth; that is, becomes weaker or ſmaller in veins? or whether, like other ore veins, as lead and *copper*, it rather encreaſes? And to mention only the *pyrites-copper-ore*, it is well known, that downwards it ſtill grows *mightier* or larger;

larger; whereas the *pyrites* iron-ore, that runs from above inwards, loſes itſelf more and more, upon the encreaſe of the former. Whence it may be probably conjectured, that iron and *copper* are, in regard of their proximate metallic ground-earth, if not one and the ſame, yet greatly reſembling each other, and differing only in the degrees and periods of coction, maturation, and exaltation: particularly, that thoſe particles, which, in the *iron-pyrites*, were to be carried no higher than to the form of iron, are, in the *copper-pyrites*, on the contrary, or *copper-ore*, to be raiſed to a higher and nobler form; that is, to that of *copper*, as what requires a different and a more thorough degree of coction and maturation.

What confirms the conjecture of the iron and *copper pyrites* having the ſame original (in particular, that the *one* is derived from the *other*) is, that the *copper-pyritæ* ſeldom begin from the *day*, or beneath the under-turf earth; whereas the *iron-pyritæ* commonly manifeſt themſelves there; nay, where the former happen to appear ſoon (which nevertheleſs is rarely obſerved) the latter do not only equally as ſoon manifeſt themſelves in huge beds, *ſtock-works*, *bellies*, and *neſts*, but are alſo gradually accompanied by the former. Yet all this does not fully ſatisfy the query; the nature of the *deepeſt*, that is, of the ſole or bottom of the mine, as far as it has been ſunk, being beſides to be conſidered.

Now, here again we are not to doubt, but that *iron-pyritæ* lodge alſo at the greateſt depth, even in the center of the earth; it being poſſible, that the ſame cauſes, that operate near the ſurface, ſhould alſo exiſt at the greateſt depths. Our experience and knowledge are, however, not ſuffi-

ciently extenſive, fully to anſwer this queſtion, a great deal of attention and caution being requiſite in forming a proper judgment on the caſe.

Now, as to the *copper-yield* in each ſort of *pyrites*, whether denominated *copper-pyrites*, or *copper-ores*, I have in various ways attempted to diſcover it, without leaving concealed the ſmalleſt ſhare of *copper*, that happened to be therein. As to thoſe that contain much *copper*, or only a *pound* the quintal, the method of extracting it is a thing well known: if firſt, according to the common way of aſſaying, they be brought, in their unroaſted ſtate, by means of pounded glaſs, to *crude-ſtone*; which *crude-ſtone*, with the uſual doſe of *black-flux* in a crucible in a wind-furnace may be reduced to *black-copper*; and this again in the aſſay-furnace to *roſe-copper*; tho' to procure the *copper*, on the ſcore of its being apt to burn away, from extremely poor *copper pyrites*, care and experience are requiſite. And, as I have had ſeveral ſorts of *pyrites* from our mines, from which neither I, nor the moſt experienced aſſayer, could extract the leaſt *copper*, I have diſcovered other ways to anſwer the purpoſe. The colour I found to be fallacious; and even extremely pale *copper-ores* to be rich in *copper*, this paleneſs ariſing from the defect of ſulphur, and the over-doſe of arſenic.

Theſe poor *copper-pyrites* I tried both in their crude and roaſted ſtate, nay even in their iron-regulus, with vinegar, alſo ſpirit of ſal-ammoniac; as theſe are ſharp waters, which *copper* readily yields to; but without the *copper* giving forth its green and blue colours, on account of their being entirely defended by the iron: and when any green caſt happened to manifeſt itſelf, it was owing to a coppery

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iron-regulus, and to *pyrites*, where the *copper* ſhewed itſelf bodily by the common proof, without the trouble of torturing with vinegar, *&c.* Laſtly, I proceeded with them in the way of a vitrioliſation, both by means of the air and fire, oppoſing ſuch vitriol to a pure martial ſort, made by art from iron by means of oil of vitriol; and thus ſufficiently pure from all *copper:* yet there was no difference of colour obſervable; though upon taſting it, its nauſeouſneſs failed not to manifeſt itſelf. But a vitriol, mixed with ſome alum, though otherwiſe entirely free from iron, as is often the caſe of that from ſhivery and black kneiſs, *pyrites-vein-ſtone*, as is that of *Braunſdorff*, and the Hungarian native vitriol itſelf, cauſes ſuch a degree of nauſeouſneſs on the tongue, as though it were coppery, that it is no eaſy matter to diſtinguiſh them: as I was long unacquainted with this, I could affirm nothing with certainty about it, but was again obliged to have recourſe to iron, which at length extracted the *copper* out of ſuch vitriols and *pyrites*, wherein I never ſuſpected any ſuch thing to be. The method in ſhort is, to diſſolve the vitriol in common water, and put a poliſhed iron wire therein; when the *copper*, though in the leaſt quantity poſſible, not only viſibly colours the iron of a *copper-red*, but alſo cruſts it over with a kind of *copper* ſkin, whilſt the iron in the mean time conſumes away, and partly goes into the vitriol mixture, and partly falls down to the bottom; and this ſo long as there remains the leaſt *copper* therein: ſo that this is the beſt way of purifying a *coppery* iron-vitriol, as ſhall hereafter appear more at large.

After premiſing in general the *yield* of other ores, we ſhall in particular treat of that of *copper*. As to the noble metals, gold and ſilver, their *yield*

in ſome ores, namely, in the *glaſſy* and *red-goldiſh* ſort, is conſiderable, or at leaſt ſo far conſtant, as that the former, when pure, and without any rocky admixture, affords always above a half, and commonly about two thirds: the latter alſo, when pure and fine, uſually above a half in ſilver, and never leſs. But then we muſt here regard the proper and eſſential characters of ſuch ores; as no ore is to be accounted a *glaſſy* ſort, that will not bear the being cut, hammered, *&c.* A *red-goldiſh* ſort may alſo happen to have ſome foreign admixture, as appears from its dark caſt at *Braunſdorff:* and thus in proportion to ſuch admixture, its *yield* falls ſhort of half. But in moſt ores, the *yield* in noble metals is ſo variable, that there is no coming at near ſo much certainty for theſe, as for the *glaſſy* and *red-goldiſh* ores.

Lead-glitter, or galena, holds ſometimes a half, ſometimes a whole *loth*, ſometimes two, three, ten, and more *loths* of ſilver; not to mention a ſort that riſes to *Marks** the quintal; among which there *break* noble veins, in particular of *white goldiſh* ore, tho' often very unobſervable. *Copper-ore* alſo, in regard of its ſilver-*yield*, greatly riſes and falls: and here I have obſerved, that when it comes to *loths*, it is of a dark-grey caſt, and then called *fallow copper-ore*; and when to *marks*, this dark-grey hue remitting ſomewhat, it comes to be called *fallow ore:* nay, the *white-goldiſh* ore, which, ſo far as I could learn, is certainly a *copper-holding* ſort, only ſo far differs from *fallow ore*, that ſometimes in ſilver-*yield* it has riſen very high, namely, to ten, twenty, thirty, and more *marks* the quintal, and on the contrary, falls in *copper:* and thus the *white-goldiſh* ore cannot, like the *red-goldiſh* ſort, properly con-

* A mark in the language of aſſayers is half a pound.

conſtitute a claſs of ſilver-ores; as being not only highly inconſtant in ſilver-*yield*, but peculiarly *coppery*, which can never be ſaid of any *red-goldiſh* ore.

As to the imperfect, or rather, ignoble metals, their ores are in more inſtances found of a conſtant yield than thoſe of the noble; as in particular, we learn from *lead-glitter*, *white* and *green-lead* ore, *tin-ſtone*, iron-*pyrites*, and *cinnabar*; *glitter*, or galena, commonly containing two thirds, nay ſomewhat above, in lead; and hitherto I have found none falling much ſhort of a half. The ſame we obſerve, and that with more certainty, of no one ore ſo much as of the rich tin-ſtone. *White* and *green lead-ore* hold ordinarily above three fourths in lead, and never under, only allowing for its incredible volatility.

Sulphur-iron-pyrites always yields about three fourths metallic, namely, iron-earth; and allowing for its volatility, neither more nor leſs than a fourth of ſulphur. *Arſenical*, or *poiſon-pyrites*, which has alſo conſtantly an iron-earth for its ground, when pure and fine, has a like *yield*, allowing only for a third, or ſomewhat over, of *fly-ſtone*, or arſenic. *Cinnabar-ore* has often ſomewhat foreign in its *mixtion*; thus not always exhibiting its due, beautiful, red character, but ſometimes appearing of a brown-red, more or leſs, almoſt like a *brown-red iron-ſtone*; but when arrived to its true degree of perfection and purity is, like the other, found in its proportion of ſulphur and quickſilver, as 1 to 6 or 7. And here it were to be wiſhed, aſſayers were more careful in noting down the ſeveral *yields* of their ores, not omitting at the ſame time to regiſter any doubts that might ariſe in the courſe of the proceſs: as by this means

we

we might by degrees arrive to certain axioms, that might be depended on, with reſpect to the metallic *mixtion* of ores.

Some of the above-mentioned ores, namely, antimony and *lead-glitter*, agree more than a little, both in their meaſure of ſulphur and metal-*mixtion*; alſo in the kind of their volatile, namely, ſulphur portion; nay, almoſt in the volatility of their metallic or ſemi-metallic portion; and beſides, in the ſeparability of their metal from their ſulphur. In particular, that theſe, before all or moſt other ores, are in their *mixtion* found of a like proportion of metal and ſulphur, as that their metal, at leaſt, ever outweighs the remaining ore-portion, but the contrary never happens. Farther, that accordingly, *tin-ſtone*, cinnabar, *glaſſy*, and *red-goldiſh* ores may be claſſed amongſt the firſt, of whoſe metallic *yield* the moſt ſolid and conſtant obſervations may be made.

Now to return to our *pyrites-copper-ore*; I have not only aſſayed various ſorts thereof, but employed all the care and attention needful on ſuch occaſions; as ſeparating, picking, and cleaning; and found their *yield* ſeldom amounting to half, nay, generally falling ſhort by 3, 2, down to 1 pound; conſequently a yield ſo various, as is not eaſily to be met with in any other genuine ore; a circumſtance that deſerves a greater degree of attention than has hitherto been thought proper to beſtow upon it; not to repeat what was ſaid of lead, quickſilver, and regulus of antimony, whoſe proper, pure ores in metallic *yield* never fall ſo low, nay conſtantly hold to one and the ſame degree of weight, without any material difference, allowing for what is loſt, from their aptneſs to volatiliſe, to be

be burnt away, and to ſcorify, nay, from inattention and negligence in the operator. The ſame may with more propriety be ſaid of tin, whoſe proper, pure ore, called *tin-ſtone*, alſo *tin-granates*, conſtantly give the ſame, and that a rich *yield*, namely, above a half. This great variety in the *copper-yield* of *pyrites* affording us no certain axioms or truths, puts us upon the neceſſity of framing ſo many claſſes of them, as there are different *yields*; and therefore copper is to be conſidered as ſomething incidental to *pyrites*.

It were to be wiſhed we had ſome external ſigns or characters, whereby to aſcertain the different *yields* of the *copper-pyrites*. The denſity, cloſeneſs, and weight of the ores are not always to be depended on. Their ſtructure, which is either *ſtellate*, *teſtaceous*, or *run*, or *melted together*, as it were, ſo far manifeſts the difference of their internal ſubſtance, as to ſhew that the *ſtellate pyrites* commonly contains no copper at all, or but very little; thoſe conſiſting of different coats, to be generally arſenical; in which reſpect they are here at Friberg called *cobaldiſh*, nay *cobald* itſelf; but as to thoſe maſſes of *pyrites*, which appear melted, or run together, it ſtill remains a difficulty to determine their yield. The colour proves a ſurer guide in this caſe; the more yellow and greeniſh the *pyrites* ſhews, the richer it proves in *copper*: yet, from the abſence of theſe colours, the abſence of *copper* muſt not be inferred. For though this inference might in moſt inſtances hold good, eſpecially in regard to ſome one particular *mine*-work; for inſtance, that of Friberg; yet the above-mentioned ſample of a certain *copper-ore* conſiderably white, ſuch as I never once after ſaw, heard, or read of, might caution us againſt entirely and ſolely

ſolely relying on the colour. The ſureſt way therefore of judging of theſe ores, where the ſtructure affords no light, is, together with their colour, to take their weight, denſity, and glittering, ſhining appearance into the account. True it is, the abovementioned *copper-ore*, which yields to the quantity of 40 pounds in the centner, appears very pale, and almoſt like a white *pyrites*; but, on the other hand, from its denſity and cloſeneſs, it muſt be of a more metallic nature, and not barely a white *pyrites* or *miſpickel*, but a body only inveſted with arſenic, and thence ought to be imagined to be more *coppery*. But what judgment then are we to form of the *fallow-ore*, *fallow copper-ore*, *copper-glaſs*, and *copper-laſul*? *Fallow-ore* is a grey ſort, darker than the *white-goldiſh*; containing between 1 and 2 *marks* of ſilver, uſually *breaking*, as we ſee at the *Croner* and the *Halſebruck*, with yellow *copper-ore*. *Fallow-copper-ore* is darker than *fallow-ore*, and therefore expreſsly denominated from *copper*, as containing more of that metal, and much leſs ſilver.

Copper-glaſs is ſtill darker, inclining much to a black, as being highly irony. *Copper-laſul* diſtinguiſhes itſelf by its ſteel-blue colour, though miſuſe has introduced the calling a yellow-greeniſh *copper-ore*, a *copper-laſul*. Among the ancients *copper-glaſs* denoted only a *copper-laſul*. But here to obviate much difficulty, theſe ores, but juſt mentioned, may well be excluded the claſs of *pyrites*, as not properly belonging thereto; though I thought it neceſſary to mention them, as they ſerve to clear up the buſineſs of ore-colours; and, in particular, to find out the marks of *copper-yields*. That the iron in the pure *iron-pyrites* appears not black, or as an iron-ſtone, but yellowiſh, is ſolely owing

owing to the ſulphur; without which there is nothing to be found in the pure *iron-pyrites*, capable of imparting ſuch colour to the iron. That ſuch *iron-pyrites*, whoſe ſulphur is only mixed with ſome arſenic, deviates from a yellow more to a white, is undoubtedly owing to the arſenic. That nothing but the *copper* heightens the yellow colour of the common iron and ſulphur *pyrites*, and makes it run to a greeniſh, is a truth as little to be doubted of. But why a *pyrites-copper-ore*, containing 20 pounds of *copper* in the centner, is not ſo eminently diſtinguiſhable in colour from that which holds only 10; and why it is often a difficult matter to know a very rich from a conſiderably poor ſort, three reaſons ſeem aſſignable: one certainly is, the arſenic, which imparts its high colour to the *copper*, as is well known from the operation of *white-copper-making*, and prevents its coming to that degree of yellowneſs or greeniſhneſs, which *copper*, with ſulphur, is wont to exhibit: and thus ſulphur is more copious, nay, as it were, more indiſpenſably neceſſary in *pyrites-copper-ore* than in *pyrites*-iron-ore; as the *ſandaracby*, or ruddy crude ſulphur, always procurable from the *copper-pyrites-ores*, ſufficiently ſhews.

The ſecond reaſon is the proportion of the ſulphur in reſpect to the remaining principles of the *pyrites*, being what I found pretty uniform and conſtant in the pure *iron-pyrites-ore*; but in the *copper-pyrites ore* not only in general, in a ſmaller, but alſo a more variable quantity.

The third reaſon probably may be derived from a circumſtance, of which I ſhall make ſome mention in the following chapter; namely, an unmetallic, crude, undetermined earth; which,

as

as in many other ores, ſo alſo is it to be met with in the pyrites; and which, both in reſpect of quality and quantity, may ſerve occaſionally to heighten, or to lower the colours of ores.

This third, together with either a defect of ſulphur, or a plenty of arſenic, may be a concurring cauſe, why the often mentioned rich *copper-ore* of Hohenſtein, has acquired ſo very pale an appearance, that were it not for its uncommon denſity and cloſeneſs, it might eaſily be taken for a yellowiſh *pyrites*, or for what it really is not. In ſuch circumſtances, we muſt be upon our guard in judging of the *pyrites* by their colours, at leaſt we muſt not ſuffer ourſelves to be miſled by the pale; though in ſuch things, where many circumſtances muſt often be conſidered together, colours afford the greateſt light, as was obſerved above, chap. II.

Laſtly, I muſt add, that in the white *pyrites* there is no copper at all. Now, whether any, or how much *copper*, there may be in *kupffer nickel*, a ſort of cobald, of a *copper-red*, and allied to the white *pyrites*, is a thing that muſt be previouſly enquired into.

CHAP.

CHAP. VIII.

Of the UNMETALLIC EARTH in the PYRITES.

THAT along with the iron and copper in the *pyrites*, there is, beſides, a fixed ſort of *earth*, which is neither ſulphur nor arſenic, neither iron nor copper; in a word, which neither is itſelf, nor can yield, any metal, is a thing deſerving a particular conſideration, as being one of the peculiar principles of the *pyrites*. Upon this head we ſhall briefly only (intending to leave the further diſquiſition of the ſubject to the more minute examination of others) conſider theſe four things; (1.) What we are to underſtand by ſuch an *unmetallic earth*: (2.) Whether ſuch an *earth* is to be obſerved in other ores: (3.) Whether ſuch can be ſhewn actually exiſting in *pyrites*: (4.) What its nature and properties are.

As to the firſt, or what is to be underſtood by the *unmetallic earth*; we muſt, firſt of all, guard the reader againſt a miſtake, in which he might be otherwiſe apt to fall, and caution him, that by no means are we to underſtand by it the adhering, interſperſed, quartzy, ſpathy matters, and the like earth, rock, or ſtone, or any thing that is ſeparable by the wedge, or diſtinguiſhable by the naked, or even by the armed, eye; ſeeing ſometimes in ores there lies interſperſed, like a ſand, a ſmall-grained, either quartzy or ſelenitical, ſort of rock, or ſtone, as I have had a ſample from the Bannat of Temeſwaer, in which an unarmed eye could

could ſcarce diſtinguiſh it. I muſt here alſo obviate a falſe notion, which, notwithſtanding the above hints, ſome might be induced to form to themſelves of what we call *pyrites-kidneys*, and balls; wherein, upon breaking them in pieces, we often obſerve all manner of ſandy, ſtoney, and often ſcarce diſtinguiſhable particles, falſely conſidered as eſſential parts in the mixtion of the *pyrites*. I have lately had one ſuch kidney, above a pound in weight, from the ſalt-pit at Bochnia in Poland, where neither externally, nor for an inch deep within it, was to be found the leaſt trace of of a rocky, or other admixed matter, as an eſſential, conſtituent part of the *pyrites*; but, quite internally, I unexpectedly obſerved ſuch; of which the *pyrity* periwinkle and muſcle ſamples are plain, palpable inſtances. But, by the *unmetallic*, fixed *pyrites-earth*, we are rather to underſtand ſuch *pyrites-particles*, as are intimately introduced into the *pyrites-mixtion*; namely, an earth, both by the volatile and fixed earth of the *pyrites*, ſo ſwallowed up, mineralliſed, and incorporated, as to be as little diſtinguiſhable as the other *pyrites-particles*, the ſulphur, arſenic, iron, or copper, either by the naked, or armed eye.

This unmetallic earth, like the other principles of the *pyrites*, is derived, as was ſhewn above, from the generation and production of the *pyrites*; from ore and ſtone-forming juices, conveyed in the manner of damps, or vapours for that purpoſe.

(2.) As to the queſtion, Whether ſuch an *unmetallic-earth* may be found in other ores, I muſt own, it was the *pyrites* gave me the firſt hint of this ſort; as in it I found ſomething which could neither

neither be called ſulphur, nor arſenic, nor a metallic earth: and, to confirm this, I examined other ores, and found a like earth in cobald and biſmuth ores. Cobald, which is uſed for making ſmalt, tolerably reſembles the *arſenic-pyrites*, or the white *pyrites*, or *miſſpickel*, both externally and internally; only that this laſt turns to a very dark glaſs, whereas the firſt has its earth changed to a beautiful blue glaſs. Now as the white, or arſenic *pyrites*, has ſome iron for its *ground-earth*, which undoubtedly is the cauſe of the black colour of its glaſs; and as the tint and colour of glaſſes commonly bewray ſomething metallic, as appears, not only by *analyſis*, but by *ſyntheſis*, as in the making of ſmalts, or enamels; ſo all blue mineral colours, whether natural or artificial, as laſul-ſtone, copper-blue, mountain-blue, blue vitriol, ariſe only from copper. And laſtly, as copper ſhews itſelf plainly in that ſort of cobald, called *kupfernickel*, it is not improbable, ſmalt may be produced from an earth, not only, in general, metallic, but, in particular, coppery: but as from cobald, by any method hitherto underſtood, only a very ſmall quantity of metal, either of copper, or any other mineral, is procurable, that bears any proportion to its earth, we muſt needs ſuppoſe its ground-earth, if not all, yet moſt of it, to be *unmetallic*, crude, vague, or undetermined; particularly, *crude-earthy*, ſandy, and thus eaſily vitrifiable: but the cobald to be employed, muſt be no *mixt-work*, but ſuch as is highly pure, and carefully ſeparated from its quartz, which not only externally adheres thereto, but often lies very tenderly and inſeparably interſperſed or mixed amongſt it; otherwiſe it would yield an over-quantity of *unmetallic earth*. This genuine ſmalt-earth is generally as one to three, in regard to the volatile, arſenical, portion; the arſenic be-

ing what has penetrated, impregnated, and formed the ſaid earth, ſo as not to become a bare ſtone, but an ore, and ſuch a ſort, as greatly reſembles a metallic, in particular, a grey, coppery, and ſilvery ore. Biſmuth-ore, which is greatly allied, and adheres alſo to cobald, leaves behind, after roaſting, (in which operation it yields a ſemi-metal, called *biſmuth*, or *marcaſite*) an earth, or ſtone, called *biſmuth ſtone*; this earth, like that from cobald, affords a more beautiful ſmalt, but no metal, in what manner ſoever treated.

(3.) With reſpect to the manner of exhibiting this *unmetallic earth* in the *pyrites*, we ſhall take notice of each of the three principal ſorts of them, beginning with the white, or arſenic *pyrites*; after ſeparating the volatile portion of which, there remains behind, in cloſe veſſels, a reguline, ſemi-metallic body, called *fly ſtone*; but in an open fire there ſublimes a grey, whitiſh meal, uſed for making arſenic, leaving behind it an earthy, or ſtoney ſubſtance, that looks greyiſh, is very light, and generally amounts to about $\frac{1}{3}$. Now, that in this *earth* there is metal, nay, iron in particular, cannot be denied, foraſmuch as it is greatly attracted by the magnet, and, in part, by means of proper additions, may be brought to yield an iron-regulus, nay, an iron-vitriol. But (1.) the iron is in a variable proportion therein, whereas the proportion of the entire fixed earth, with reſpect to the volatile part, comes pretty near to an equality. I have remarked, that not only one ſort of *arſenic-pyrites* earth is more affected by magnetiſm than another; nevertheleſs, that it preferably turns to iron, as I have had an inſtance of a ſort from Fahlun in Sweden. (2.) But this *white-pyrites* iron is in a very ſmall quantity, that is, ſcarce $\frac{1}{20}$, in com-

compariſon of the remaining fixed earth. (3.) This unmartial reſidue is by no methods reducible to any other metal; and tho' in the intended metalliſation many actual iron particles may be ſcorified, or vitrified, as may eaſily happen in iron, nay, in copper proofs, with an undue degree of fire, or doſe of *additions*, yet this cannot always be the caſe; and certainly we have reaſon to believe, that the glaſs, or ſcoria, to which the fixed white *pyrites earth* runs, is moſtly a crude, *unmetallic earth*. As to the yellowiſh, or ſulphur *pyrites*, there is, by the magnet, and the uſual *ſmelting-proof*, more iron in it than in the white *pyrites*: ſo that ſome of them amount to 50 or 60 lb. of iron in the centner, or quintal; whilſt others, or rather the moſt, in particular the ſpherical, and thoſe the pureſt *iron-pyrites*, ſeldom yield more than between 10 and 12 pounds. And again we ſee, that, beſides the ſulphur part, which is generally about $\frac{1}{4}$, and the metal, which is not $\frac{1}{2}$ of the $\frac{3}{4}$ parts of the fixed earth, including alſo the ſcorified iron-earth, the half or above the half, which is neither ſulphur, nor metal, muſt be a crude earth. Laſtly, of the copper, or yellow *pyrites*, we may affirm the ſame as of the yellowiſh, as being nearly allied to each other.

(4.) What the proper nature of this *unmetallic earth* may be, cannot ſo eaſily be determined; we muſt therefore reſt contented with the bare knowledge, that there is, in reality, ſuch an earth, tho' incapable of exhibiting it pure and in its unvitrified ſtate. I call it a crude earth, becauſe from it, as from an unformed matter, a metal may be produced, if either the matrix prove not barren or untoward, or there be no want of impregnating juices, or of a proper length of time for compleating the maturation and coction.

CHAP. IX.

Of the SULPHUR in the PYRITES.

AFTER having treated of the metallic, as well the martial as venereal, and of the unmetallic earth, and conſequently of thoſe parts of the *pyrites* which are fixed, we now proceed to conſider the others; and firſt, the *ſulphur*, which is a body peculiar to the mineral kingdom alone, as no one ſort of ore is to be found without it; ſome partake of it in a larger, others in a ſmaller proportion; though it is ſcarce, if at all, to be found mixed with tin, biſmuth, and cobald: it mixes indifferently well with arſenic, alſo gold, more readily with ſilver, and ſtill more ſo with lead, iron, and copper, but, above all, with quick-ſilver, and regulus. As to tin, I never yet met with any tin-ore, that ſhewed the leaſt trace of *ſulphur*, but rather a pure *poiſon-meal*, or arſenic; though this tin ore be not eaſily ſeparable from *wolfram*, a kind of mock-tin, or an irony tin mineral, which muſt therefore have ſome *ſulphur*. A genuine ſmalt-cobald, in this reſpect, greatly reſembles tin; and from biſmuth-ore, as ſuch, to extract any *ſulphur*, would be more than a little extraordinary. Arſenic, when contained in the mineral called *poiſon-pyrites*, or *miſſpickel*, may admit of ſome *ſulphur*, but ſmalt-cobald with none; a circumſtance worth remarking.

Further, though regulus of antimony be ſo nearly allied to biſmuth, as appears by a variety of experiments,

periments, and tho' the former is entirely impregnated with *ſulphur*, yet that the latter ſhould not bewray the leaſt appearance thereof, is ſomething uncommon.

Silver manifeſts ſtill more of it, not only that incidentally lodged in other *ſulphurated* ores, for inſtance, lead glitter, copper-ore, and *ſulphur-pyrites*, *white-goldiſh*, *fallow* ores, and *fallow-copper*-ores; but in its own peculiar ores, as the *glaſſy*, and, in ſome degree, the *red-goldiſh* ores.

As to gold, it is not certainly known with us, how far, and how readily *ſulphur* lodges in it, as I have not hitherto ſeen a proper gold-ore; and as it is ſtill a queſtion, whether the ſpangles of gold, to be met with in veins, are not rather native, that is, only lodged there, and not in an ore-ſtate, or mineraliſed by means of *ſulphur*; yet I would not maintain the impoſſibility of ſuch a ſtate, nay, rather hold, that, where 'tis reduced to genuine ore, it is ſo, not by means of arſenic only, though principally, but alſo of *ſulphur*; beſides which, there is no third body in the whole compaſs of the mineral kingdom, ſo capable of reducing metals to an ore-ſtate.

But be this as it will, *ſulphur* is more readily found along with lead, copper, and iron, as appears from lead-ores, copper *pyrites* and ore, and iron-*pyrites*, yet not ſo peculiar to theſe metals, as it is to regulus and quickſilver; ſeeing iron-ore is ſometimes to be found without any diſtinguiſhable *ſulphur*, ſuch as moſt iron-ſtone is, in particular, *glaſs head*. Copper-ore I have found without *ſulphur*, as, a copper-laſul from Lapland; alſo lead-ore, entirely without any, as appears from the

white and green lead ores; but to find quickſilver-ore and regulus without *ſulphur*, would be a prodigy in nature.

Sulphur is more frequently found with the ignoble, rather than with the nobler metals, in their ore-ſtate, and with it, ſometimes, arſenic is combined in larger or ſmaller quantities; a circumſtance not to be affirmed either of quickſilver, or regulus.

Iron and copper, as well as quickſilver and regulus, greatly affect *ſulphur*, which, when without all other metals, is never without both theſe laſt; and in the former too in ſo large a quantity as in the often mentioned metallic middle ſubſtances, or *electra*. In a word, *ſulphur* reduces iron and copper to an ore-ſtate, and forms them into *pyrites*; yet not always in the ſame manner, or proportion.

As to the white *pyrites*, I, for a long time, doubted whether it contained any *ſulphur*, 'till a perſon, employed in the manufactures of *ſulphur* and ſandarach, would, right or wrong, perſuade me, that a ſandarach might be made from white *pyrites*, without *additions*; whence it follows, that it muſt neceſſarily contain *ſulphur*, without which no ſandarach can be prepared. But to omit mentioning now, that I never could diſcover any by my repeated proofs, I found it to be a bare aſſertion, without any foundation; a thing but too common, both at the mines and huts. I cannot, however, deny to the white *pyrites* (though entirely cloſe as ſteel, pure, and without any obſervably interſperſed *ſulphur-pyrites*) any the leaſt matter of *ſulphur*.

In *copper pyrites*, as that holding but little copper, is thus called at Friberg; and *copper-pyrites-ore*, (by which

which I mean what is there called copper-ore, or the *pyrites* rich in copper) poſſeſs *ſulphur* in ſuch plenty and proportion, as might almoſt make it looked upon, not as an incidental, but as an eſſential, conſtituent part thereof; and this ſo conſtantly, that let a *copper-pyrites-ore* be ever ſo arſenical, it is never without *ſulphur*. And here the following remark may properly be made, namely, that *iron-pyrites*, ſo far as the *white-pyrites*, on account of its very ſmall portion of iron, may be called ſuch, may ſooner exiſt without *ſulphur* than *copper-pyrites*.

In genuine *iron-pyrites*, containing the leaſt, or no copper at all, the *ſulphur*, in general, amounts to between $\frac{1}{4}$ and $\frac{1}{3}$ of the whole. To mention only the principal ſorts; that from Ehrne-Schlange gives 28 pounds of crude *ſulphur* the centner, or quintal; from Pretzſchendorff, 30 lb. 24 *loths*; from the Rautencrantz, at Johan-Georgen-Stadt, 30 lb. 24 *l.* from the Halſebrucke, 36 lb. 16 *l.* from Braunſdorff, 25 lb. 16 *l.* from the Schloſsberg, at Toplitz, 27 lb. 16 *l.* from Almerode of Heſſe, 26 lb. 12 *l.* from Alt-ſattel, near Egra in Bohemia, 26 lb. 16 *l.* from Boll, in the territory of Wirtemberg, 26 lb. the *ſhiver-kidneys* of Goſlar, 24 lb. the Swediſh *pyrites* of Nericia, 25 lb. the *pyrites-kidneys* from the ſalt-pit at Vilizka, 26 lb. the *pyrites* from the Bannat of Temeſwaer, 27 lb. 10 *l.* the *pyrites* from the three Wiſemen's Levels at Schemnitz in Hungary, 23 lb.

And here we are to remark, (1.) That in cloſe veſſels, as retorts, the above aſſigned proportions of crude *ſulphur* are with difficulty, and commonly ſcarce to one fourth procurable; but an open fire, ſuch as is that under the muffle, fully forces out what

remains behind, which is doubtleſs a *ſulphur*, as appears from the odour of the exhauſted *pyrites-earth*, though not to be retained.

(2) The *pyrites*, that in crude *ſulphur-yield* exceeds one third, is to be ſuſpected to partake of arſenic; as is the caſe of the *Halſebrucke pyrites*, which, in its *ſulphureous*, and other volatile portion, amounting to 36 pounds in the center, and conſequently above one third is remarkably arſenical, and therefore called *cobald*.

In *pyrites*, impregnated with arſenic, as is commonly the ſort where copper lodges along with the ground-earth, it proves a difficult matter to make a calculus of the *ſulphur*; ſuch *pyrites* readily caking, and running together in the fire, and the more ſo, by how much richer it is in copper; the reaſon, doubtleſs, is principally owing to the arſenic; for, the *white pyrites*, which abounds in arſenic, does the ſame; that is, running together, it uſually cakes: ſo that the arſenic to the *ſulphur*, in the *copper-pyrites*, or copper-ore, rarely exceeds one fifth or one ſixth.

Now, the *ſulphur* procured from *pyrites*, particularly from the yellowiſh, or the ſort called *iron* and *ſulphur pyrites*, generally manifeſts a yellowiſh grey caſt, and is occaſionally called either *crude ſulphur*, becauſe it comes from the firſt proceſs, and is ſtill unpurified; or *caballine*, or *horſe ſulphur*, as it is proper enough to be uſed for diſeaſed cattle. This *crude*, or *horſe ſulphur* is re-committed to the retort, and once more diſtilled or fined; whereby it turns out beautifully yellow, pure, and fine, the foreign arſenical matter, called *ſulphur-ſlag*, remaining behind at the bottom of the retort.

I can-

I cannot omit ſuggeſting here ſomething very remarkable; whether to call it a new diſcovery in mineralogy, particularly in the doctrine of *ſulphur*, I know not; which, in ſhort, is this, that in the *crude ſulphur*, there is an actual iron-earth contained, which not only is readily acted upon by the magnet, but is alſo *metaliſed*.

For if you take the *ſulphur-ſlags*, and burn them in a crucible or pot, you procure a greyiſh, aſhy earth, which the magnet attracts, and which, by proper *additions*, may be reduced to an iron-regulus; and this not only when the *ſulphur* is treated in an iron retort, the uſing which might give ſuſpicion of the acid ſalt of the *ſulphur* having corroded and diſſolved ſome of the iron of the pot, but alſo in earthen retorts.

We have here beſides two remarks more to make: (1.) That the above is a certain truth, which may often clear up an experiment, that may happen to be made with *ſulphur ſlags*, and contribute to attain the knowledge of a natural body; whether the iron it holds, happen to be derived to it in an incidental manner from the veſſels, in the courſe of the purification, or in the firſt *deſulphuration* ſublime along therewith from the ground-iron-earth of the *pyrites*.

(2.) The more clearly to diſcloſe my thoughts on this head, I am in general to enquire, whether it would be any abſurdity to ſuppoſe the tender iron-earth, as it is in the *pyrites*, to be at the ſame time volatiliſed in the *deſulphuration* of the *pyrites*? The copper-earth is, however, fitted for this volatiliſation, as the copper-particles in the *pyrites* adhere

here more closely to the *sulphur* than the iron-particles do. But all that can be hence inferred is, that the copper-particles may be more adapted for volatilisation than the iron-particles are; as it must be allowed, that the grossest earthy metal-particles, as iron and copper, nay all imperfect metals, may barely, by the action of the fire, without any additional assistance, be volatilised.

What may help to remove all difficulties, is the having in our eye the two following important and repeatedly confirmed rules:

(1.) That some matters, when accompanied, or combined with something, even not so essential to the design, usually shew themselves, both *passively* and *actively*, of a very different habitude; either more adapted and active, or more powerful and operative, than when employed separately.

(2.) That metallic earths are in their mineral state of a quite different aptitude, than when brought into a metallic body, and smelted. Silver, as a metallic body, will be readily allowed to remain unvolatilised, but combined with common salt, will prove fugitive. The vitriolic acid is one of the most powerful, penetrative, active things in nature, yet deprived of the inflammable earth it possesses in the *sulphur-mixtion*, it can never produce the same effects that it does, when treated in the form of *sulphur*: and the effects of sulphur itself upon metallic earths are owing to its combined state in the mineral of *sulphur*, namely, the *pyrites*.

The grounds of these two practical rules depend sometimes barely on giving a steadiness and body

to

to the matters under treatment, that they may not go off too ſoon in the fire, but have time either to work or to be worked upon; as we ſee from the production of *ſulphur*, where the alkali is only given as a body to the vitriolic acid; ſometimes on intimately mixing different things together, though in themſelves improper for the intended proceſs; when new combinations, qualities, and effects, muſt needs be produced.

Now, to apply all this to the volatiliſation of the iron-earth of the *pyrites*; it is certain, that this is not ſo eaſily effected with iron itſelf, as with the iron-particles, ſtill exiſting in the ore or *pyrites*: and what is deciſive, take a *crude ſulphur* made in clay veſſels, diſtil or burn it off, and examining the earth remaining behind, with the magnet, *this* latter will be found to attract the *former*.

Whether, and how far, the coppery earth goes in part over, in the diſtillation, or *deſulphuration* of the *pyrites*, along with the *ſulphur*, as I have not been able to make *John Agricola*'s experiment, muſt be left to be conſidered, and reſt upon the truth of his relation, which is as follows:

'Having once made an *oleum ſulphuris*, or oil 'of *ſulphur*, the *fæces*, or remainder, I reverbe-'rated for fourteen days in a moderate fire; after-'wards committed them well luted down to a 'wind-furnace, giving for ſix hours a ſtrong fire; 'then I wanted to calcine the *fæces* quite white, as 'my intention was to make ſomething elſe of 'them. Now, upon breaking up the crucible, I 'found on the upper part, a few *fæces*, not white 'but grey, and beneath, a beautiful regulus, of a 'blood-red colour, and very ſparkling. I won-

'dered

'dered what it might be, as being well aware, that 'not the leaſt thing, beſides the ſulphureous *fæces* 'had come into the crucible. Upon taking out, 'it proved heavy, and tried under the hammer, 'it ſtretched almoſt like lead: upon clipping with 'the ſheers, it proved internally ſomewhat yellow-'iſh, but a beautiful fine copper, which gave me 'no ſmall ſurprize. The goldſmith alſo, upon 'wire-drawing it, found it not only malleable, but 'of a very beautiful colour. Upon a repeated ig-'nition and extinction in urine, it had almoſt ac-'quired the colour of *crown-gold*. It has been 'often matter of reflection with me, why I procured 'no other metal but copper; for, I well knew 'this *ſulphur* was not derived from a copper, but 'from a gold pyrites. But at laſt I found the rea-'ſon: for, though there was not any one mineral 'or metal added, only the *ſulphur* firſt diſſolved 'in linſeed oil, from which no metal can ariſe; I 'thus concluded, that a ſtrong metallic ſpirit, tho' 'deemed only an excrement, and forced off by a 'ſtrong fire, lodges in the ſulphur *.'

Many things in this relation want to be cleared up, and much to be remarked upon. In the firſt place, it is pity our author did not ſpecify the quantity of the *ſulphur* employed, and of the copper educed; a piece of inaccuracy but too common with writers on theſe ſubjects. Again, he is under a miſtake, in that he conſiders linſeed oil, as of little uſe in the buſineſs of *metalliſation*; ſince it is not a bare *tranſient* but an *immanent* inſtrument, or rather *materially* contributes thereto.

His making *gold pyrites* and *copper-pyrites* two different things is a miſtake, as I have ſufficiently ſhewn

* Joh. Agric. uber Poppii Chymiſche Artzneyen im tractat. de ſulphure, p 855.

ſhewn above, chap. III. There are ſo many *pyritæ* containing copper, that ſcarce one in a hundred is without it, or that conſiſt entirely of iron. A *pyrites*, that, preferably to another, yields gold, muſt always poſſeſs iron or copper, or both, for its ground-earth. And I have remarked, that ſuch *pyritæ* are ever coppery, nay the very richeſt copper ores; and, in the other caſe, ever purely arſenical, or the *white pyrites*. Now, in the laſt place, whether it was an actual *gold-pyrites*, or no, we are to underſtand, that *pyrites breaking* in fiſſures and veins, is ſeldom without ſome little copper. So that our author might have ſaved himſelf many uneaſy reflections about the cauſes, whence his copper might ariſe; and alſo have ſpared himſelf the trouble of imagining a *metallic ſulphur ſpirit*; as he needed only to have put the alternative; either the copper is along with the *ſulphur* educed bodily out of the *pyrites* in form of the moſt ſubtil earth; or generated, as a new production, out of the *ſulphur*, or its peculiar earth, with the addition of linſeed oil, or its fatty earth; alſo for a certainty, with the addition of the material, fatty particles of the fire.

It is, however, probable, the above copper was not generated but educed: for, in the firſt place, the volatility, or at leaſt, the volatiliſation of all imperfect metals in general, is a plain caſe. (2.) We have a peculiar inſtance in iron, which is moſt proximately allied to copper. (3.) The *ſulphur*, which muſt here ſerve as the vehicle, adheres longer and cloſer to the copper than to the iron. (4.) The volatility of copper aſſayers experience but too often, upon too briſkly roaſting its ore; when they remarkably educe a leſs quantity of copper, than when together with care and time they employ a gentler fire.

Now

Now according as the *pyrites*, out of which this and the other *ſulphurs* are *driven*, the *ſulphur-ſlags* of each ſort procured, happens to be very irony or coppery, ſo the earth remaining behind of theſe ſlags, may at one time take more iron, at another more copper. Yet it may well happen that in the courſe of *deſulphuration* and purification, ſome change of iron into copper particles may be effected, by means of the energy of the *ſulphur*, as both thoſe metals are proximately allied to one another: by this change or tranſmutation, no wide leap, but an eaſy tranſition rather is produced in nature; not only to the *patient*, namely, the metal, ſtanding highly receptible, but the *agent*, namely, the *ſulphur*, in the rank of one of the moſt powerful in nature; that if common *ſulphur* doth not tranſmute iron into copper, or rather does not fit an irony earth for a coppery one, it will remain for ever untranſmuted.

As to the habitude of *ſulphur* to the metal-earth, entangled therewith in the *pyrites*; it becomes a neceſſary queſtion, whether either the *ſulphur* aroſe at the ſame time with, or whether it gave riſe firſt to the metal-earth, and thus exiſted previouſly to it.

That all *pyritæ* were not originally created, but generated at different times ſince the deluge, and ſtill continue to be generated, is a certain truth, as I have ſhewn in chap. V. Now let any one imagine to himſelf a luty, loamy, and the like marly earth-bed, which is peculiarly adapted for the conception of ſuch ore; I there find only one ſort of particles, either not manifeſtly ſuch, or in all reſpects the ſame as the *pyrites* conſiſts of; and, as one

one might be apt to imagine, ſuch as it might be ſuppoſed to be run together and formed of.

We ſhall omit mentioning the metallic ground-earth, as being what is at leaſt *in potentia*, ſo that nature may, with eaſe, completely fit it for the *pyrites-mixtion*; nay, which already appears to be pretty well fitted; as art, which is far from being able to call in aid ſuch auxiliary means, or far from having that time for the purpoſe, ſhews the poſſibility, from *Becher*'s famous experiment on loam and linſeed oil, of ſuch earth being proximately fitted for the production of iron, alſo of *pyrites*. But we would only enquire, from whence the *ſulphur* is to be derived to it? On the ſpot, where the generation is to happen, there is none.

But it will, for inſtance, be alledged, that ſuch a lute, wherein the *pyrites* appears to run neſt-wiſe, muſt, e'er the production of the *pyrites*, have been of quite a different mixtion and nature from what it is at preſent; ſo that its preſent ſtate renders it unfit for any further conception. Now, ſhould we ever allow the places for the production of minerals, partly in the ſtate the creation left them, partly as the deluge has affected them by new mixtions to be become more unfit by exſiccations, exuctions, indurations, nay, even petrifications, whence ſhall we then derive the *ſulphur* to the *pyritified* periwinkle and muſcle-ſhells, which doubtleſs owe their riſe to the deluge? Should it be even preſent upon the ſpot, and ſuch earths happen then to be of a quite different mixtion and nature, from what they are at preſent, yet it is impoſſible to conceive, it was formally and actually preſent, or that *fluxwiſe*, like a *ſulphur* melted in the fire, being brought thither, it had, like a ſeed, collected and lodged

lodged itſelf in certain cavities and matrices, and there concocted, penetrated, and elaborated the matters it met with, and laſtly, hardened them into ſuch lumps, balls, *kidneys*, and *nuts*, as we find.

To come to the truth of the matter as near as may be, if not to a poſitive demonſtration, yet a high probability, let us conſider thoſe bodies called *druſe* and *ſinter*.

Upon both theſe we, among other ores, find *pyrites*, not in a flux or run ſtate, but as ſo many ſmall ſtones or cryſtals, in figure like the following ſalts; *viz. tartarus vitriolatus*, *arcanum duplicatum*, common ſalt, &c. which thus uſually ſhoot from their ſeveral waters. Theſe cubical and variouſly angular *pyrites-corpuſcles* ſit ſo looſe upon the rock and tacks of the *druſe*, as to make it evident, they did not ſprout out of the ſubjacent rock itſelf, but were ſprinkled or ſown thereon: and really the caſe is ſo; namely, that they are damp wiſe ſprinkled upon theſe bodies, as I have ſhewn above, chapter V.

The queſtion therefore is, whether thoſe parts of the *pyrites*, we afterwards diſcover upon reſolving it, exiſted in the mineral damps in a determined, formal, actual ſtate; or, whether they were not firſt formed and produced in the courſe of forming the ore itſelf? A queſtion of ſome importance, as it no ways follows, that becauſe upon analyſis, we find the *pyrites* principally to conſiſt of ſulphur and iron; that therefore it is alſo neceſſarily produced from the ſame materials; nor that, as many might be apt erroneouſly to imagine, the *ſulphur* is the *metalliſing* principle; things that lodge near, and in each other, are not always to be taken for the natural

mutual origin of each other; though *ſulphur*, when actually preſent, and chiefly in its ore, muſt be allowed to have ſome efficacy. The mineral damps, that lodge any where for mineraliſation, may happen to be of different *mixtions* and natures, yet, doubtleſs, in their particles, are ſtill in an undetermined, and, as it were, *chaotical* ſtate; in which, though caught and examined freſh, neither the *ſulphur-earth* apart, nor the metal-earth; neither the *dry*, nor the *moiſt*, are ſeparately diſtinguiſhable: either they are found in a kind of ſeminal ſtate, wherein the parts of the body to be formed are not yet diſtinctly exhibited or elaborated, tho' they lodge *potentially* therein. And though the receptivity and re-action of the bed or matrix, length of time, the acceſſion of different matters, and other accidental circumſtances, have undoubtedly much influence on the formation of different ores; yet I affirm, that in the production of the *pyrites*, we ought to imagine an *influx* of actual *pyrity*, formally *ſulphureous*, and corporally *metallic* damps; but to the formation of *ſulphur*, *pyrites*, and *metal*, damps proximately and reciprocally adapted, are neceſſary.

For, in the firſt place, from the oppoſite opinion, it muſt be preſumed poſſible, from *ſulphur* and iron earths, to make, or compound the *pyrites*; but of this there neither is, nor ever can be any inſtance: and farther, ſuppoſing that art could exhibit any ſuch experiment; where ſhall the metal-earth, in the laboratory of nature, be found to be added thereto? On the *druſe*, as being quite pure and cloſe, it is not to be met with; and yet there the *pyrites* is often found in great plenty and large maſſes; to ſuppoſe it ſprinkled along with the

ſulphur, by way of damp, in a metal form, is as difficult to reconcile with experience.

Pyritæ reſolve themſelves into their preſent conſtituent parts, and forſake their proper mixtion, as ſhall be ſhewn in the chap. on vitriol; but theſe parts thus forſaken, do not therefore remove from each other, nay, do not ſeparate from each other, even for a ſingle moment; but in the courſe of that motion which brings about the diſſolution of the *pyrites*, the ſulphur-acid ſwallows up the iron-earth, and becomes conjoined again in a different manner: what remains ſeparated from this new vitriol-production, may well be deemed no other but the metal-earth; and as to the *ſulphur*, there is little or nothing ſaved, but generally all of it is deſtroyed; yet as there is certainly much *ſulphur* acid requiſite to the production of vitriol; nay, from the very ſmall metal-yield of the *ſulphur*, and ſo much metal-earth or ochre reſidue, we muſt conclude, that were there more *ſulphur* in the *pyrites*, more vitriol would have been generated, and thus more *ſulphur* become incorporated with the iron in the vitriol.

Thirdly, there are other ores that may happen to be ſomewhat *ſulphureous*, and diſſoluble, and by their diſſolution yield *ſulphur*, and form *ſulphureous* damps, or *weatherings*, and yet be leſs adapted to the production of matters, or damps fitted for *pyritification*; wherein the parts of the *pyrites*, eſpecially the metallic, ſhall (if we allow it to contain the *ſulphureous* parts) formally exiſt; ſeeing all other *ſulphur*-ores, that are not *pyrites*, afford no iron, as the latter do.

Fourthly,

Fourthly, from the ſtructure or texture of the *pyrites*, particularly the round ſort, we ſee it is become what it is, through length of time, and by means of coction. The round ſort is either teſtaceous or radiated, and by both ways of ſtructure, it exhibits ſuch proofs of its origination, as are not to be ſought for from an external accumulation, but from an internal concocting, fermenting, tranſmuting elaboration: I ſay, from the origination, or formation of *pyrites*; (and this I mean not of the configuration or external form, but of the internal eſſence and mixtion of the *pyrites*;) for, indeed, an accumulation, not of matters actually *pyrity*, but of matters adapted to ſuch productions, muſt both be granted, and muſt happen. Yet in clayey, loamy, ſhivery, marly beds, where *pyrites* is peculiarly found in *kidneys*, ſo large an accumulation of matters, derived from other quarters, is not ſo much to be expected, nor is it neceſſary (as there the ſubjacent fine earth, at leaſt the iron portion, contributing to the formation of the *pyrites*, is already proximately prepared for it; which, to its concentration, collection, and mineraliſation, together with ſome acid, or even ſulphureous damps, only wants ſome degree of coction) as in thoſe *pyritæ* rather, that lay upon *druſe*; where nothing earthy is obſervable; from which, as from a *ſubtratum*, ſo much metallic matter, as is to be found in *pyrites*, could have been generated.

Upon the whole, the *ſulphur* in the *pyrites* firſt truly becomes what it is, and was not before formally therein; in the ſame manner as other fixed *pyrites*-earths, which, (previous to the *pyritification*, were crude, though not ſo very foreign to

this work) muſt by coction be more proximately prepared, and rendered metallic.

Now, in order to anſwer the queſtion; *viz.* what analogy the *ſulphur* in the *pyrites* has to the metal-earth, we muſt here diſtinguiſh the times. Firſt, if by it we intend only the primordial origination of the *pyrites*: in this ſenſe, the ſulphur in the *pyrites* is not the *metalliſing*, nay, not the *mineraliſing* principle; for, how ſhould it, when it did not exiſt? And though the inflammability of mineral or mineraliſing damps ſhews ſomewhat of a *ſulphureous* nature, yet it does not follow, that they are poſitively *ſulphureous*: thus the acid of ſuch earth-*weatherings* ſhews a part, and not the whole of the *ſulphur*.

But, were we to ſpeak with propriety, not of the *ſulphur* itſelf, but of the parts that are to become *ſulphur*, it ought to be obſerved, that in the buſineſs of generation, the matter may be conſidered as *active* and *paſſive*; the former as the moſt tender, fugitive, and penetrative; and the latter (or what is to become the metal) the heavieſt, coarſeſt, and denſeſt: though in generations, that is, in productions of a third thing out of two others, both parts ſo act and re-act, as thereby to form a new production.

(2.) If by the queſtion be meant the analogy of the *ſulphur* to the metal-earth in the *pyrites* already formed, ſuch as we find it: to me it ſeems like the juice, in reſpect to the remaining dry body; or, as a material cauſe and property of *mineraleity*; according to which the *pyrites*, like all other proper metal-ore, is diſtinguiſhed from a formal metal,

or

or formally metallic earth; on which ſcore, *pyrites* may be called, neither an iron-earth, nor iron itſelf, but a *ſulphurated* iron, or iron-earth: and laſtly, that the *ſulphur* and iron-earth are mutually moved or acted upon by each other, and connected together, like two members or links in a chain; where there is neither *agent* nor *patient*, but both are equally *paſſive*; in which caſe a third body muſt intervene; as happens in the vitrioliſation of the *pyrites*; where not only the chain, but each link therein, breaks aſunder, namely, the *ſulphur* in particular, ceaſes to be a *ſulphur*, and commences to be, what it muſt be, for exhibiting a vitriol.

This third conſideration leads me to a circumſtance the moſt important of all, and which gave occaſion to this queſtion, which otherwiſe may poſſibly appear uſeleſs; namely, an opinion, that the metals in the ores do, by means of the *ſulphur*'s activity, not only grow, but become more enobled: a ſurmiſe, which, if it doth not unhappily betray the enquirers into all the falſe concluſions and vain idle proceſſes about metals and their melioration, yet it helps to prevent the diſcovery of other uſeful, practical truths. For, tho' we are ready to confeſs *ſulphur* a very powerful principle in the mineral kingdom, yet in any capital imitation of nature, we are not to ſtrain or over-do our conceptions of it.

Where then is the *ſulphur* or agent in ſuch proceſſes, when two bodies, which partly are only a crude, unſaline, unſulphurous, nay even unmercurial earth; and partly, a metal already ſmelted out of its ore, come together into union, and ſuch a degree of motion, as that the firſt not only incorporates with, but alſo proves ſimilar to the ſecond;

conſequently, to be corporally metallic, nay a noble metal; as the celebrated *Stahl* knew an inſtance of a certain earth and a ſilver; and which was not unknown to other operators? And is then foſſil calamy, which not only tinges, but alſo in its very ſubſtance enters into the body of copper, and therewith becomes metallic, a *ſulphur* alſo, or derived from *ſulphur?* I cannot find it is.

Finally, *ſulphur* certainly is a powerful, active, mineraliſing, and peculiarly operative matter, not only in reſpect to that metal-earth, with which it was blended, and conſtituting, for inſtance, the *pyrites*-maſs, but alſo, after ſeparation from the *pyrites*, or any other body, in regard to other foreign earths, with which, after due preparation, it is put in a proper degree of coction: and this is the third analogy of *ſulphur* intended by the above queſtion.

The firſt was the analogy of the *ſulphur*, or rather of the parts that were to become *ſulphur*, to the metallic earth, or the earth that was to become ſuch, as we may conceive it in the firſt formation and production of the *pyrites*. The ſecond, the analogy of the *ſulphur* in the *pyrites* already formed, as it now is, in a ſeeming ſtate of reſt or inactivity. The third, its analogy, out of its mineral, when ſeparated from it, or even left therein, and ſomething elſe applied, with which, by means of the external warmth, it may be brought into action.

'Tis however certain, *ſulphur* manifeſts ſomething that is active, powerful, and operative, nay maturating, graduating, and tranſmuting, both in its ſeparate and combined ore ſtate; ſometimes

times more one way, ſometimes more another, according as the ſubject happens to be qualified by nature, or prepared by art; alſo according to the nature of the fire, the proceſs, and other circumſtances.

As to *ſulphur* in its ſeparate ſtate, 'tis certain, it mineraliſes, or reduces metals to an ore-ſtate: in particular, this holds good of lead, which it reduces to a form, tho' more earthy and ſooty, and thus very indiſtinct; yet ſuch a one, as will here and there eaſily manifeſt ſmall eyes of *glitter* interſperſed.

It reduces alſo to an ore-ſtate the regulus of antimony, ſo as to make it greatly reſemble a crude antimony. It turns quickſilver to cinnabar; ſilver, eſpecially when reduced to that white calx, from which the *Lunæ cornua* is made, to a maſs, little or nothing diſtinguiſhable from that richeſt ſilver-ore, called *glaſſy*. It alſo mineraliſes tin, yet ſo, as to appear like an antimony rather than a tin ore.

Further, *ſulphur* metalliſes crude earth, from which otherwiſe no metal would be procurable; yet, with this remarkable difference, that it ſooner reduces it to a noble than ignoble metal: as to the production of theſe laſt, a part only of the *ſulphur*, namely, its fattineſs, is better adapted than the whole body of the *ſulphur*. It exalts the earths of imperfect metals, and makes them approach conſiderably near to ſilver, and probably to gold, as I found by experience, after having found out, and duly worked the proper ſort. This I can with confidence affirm of the *reguli* of lead and antimony. And I conclude from experience, that the hiſtories

of the many lead and tin proceſſes mentioned by Kelner, ought not to be rejected, as they certainly carry appearances of what has really happened, notwithſtanding many others have miſcarried in their attempts, to imitate his experiments. To them alſo belong the cinnabar-proceſſes, where again the *ſulphur* comes principally in play, and which, by paſſing through the hands of impoſtors, have fallen into diſcredit.

On the head of the lead and tin proceſſes I ſhall only mention, that the buſineſs depends, in ſome meaſure, on the due preparation of the metal or earth, particularly on its moſt intimate ſubtiliſation; to the ſame purpoſe is alſo neceſſary ſuch a degree of warmth, as that the *ſulphur* ſhall juſt come to exert its activity, without being made to run. As to the *ſulphur*, while yet in its ore-ſtate, I have made numerous proofs with *ſulphur-pyrites*, and found, that in certain circumſtances, there may, in regard to the exaltation of the metallic earths, or the metalliſation of the crude earths, ſomething be performed therewith, which is not performable with *ſulphur* alone. And this is a ſufficient hint, without being more explicit, to a diligent enquirer into nature.

But I cannot help obſerving: (1.) The extraordinary nature of native calamy; namely, that an earth, ſuch as that properly is, which of itſelf affords no metal, except a very inconſiderable ſhare of iron, ſhould, upon being mixed with a body appropriated to it, for inſtance, copper, become almoſt intirely, as is well known, metallic, and incorporated with the copper, without deſtroying its malleability, and conſequently its true metallic character.

(2.) That

(2.) That taking certain lutes, as chalk, and roaſting it ſoftly and gradually along with *pyrites*, a *ſilver-grain* will certainly be procured, otherwiſe not procurable from ſuch an earth, and which conſequently may be juſtly affirmed not to be in it, but rather maturated, concocted, made, or tranſmuted by it.

Laſtly, That here we ſeem to diſcover a foundation, that may tend to the improvement of ſmelting ores; not to mention the iron, lodged with the *ſulphur* in the *pyrites*, which principally contributes to the buſineſs of fluxion and ſeparation.

As the metallic earth, joined with the *ſulphur* in the *pyrites*, is two-fold, namely, iron and copper, the former at all times, the latter often at the ſame time therein, it remains to enquire, what their different connection with each other uſually is.

(1.) Sulphur endures being ſeparated very eaſily from the iron earth, ſo as ſometimes to lie looſe therein; whereas it clings more cloſely to the copper earth, inſomuch that it is often perceived to flux along with, rather than part from it; as appears not only from copper-proofs very readily caking together, but from the *copper-ſtone* at the huts; which, after having gone thro' a number of fires, both in roaſting and ſmelting, ſtill exhibits many large lumps in the form of real yellow copper-ore. 'Tis true, arſenic, which always lodges in the copper-ore, but never in pure *iron-pyrites*, may be the means of this cloſer union; nay, is of itſelf alone capable of effecting this, and with its metallic earth adhering to it, of coming into an intimate union, namely, into flux; as it directly ſhews this (upon committing

ting it to a ſudden briſk fire in a crucible in the wind-furnace) in *Miſpickel*, along with that earth, which, in a great meaſure, is martial, and moreover, very crude. The reaſon, doubtleſs, is, that arſenic, as a ſemi-metallic body, comes nigher than *ſulphur* to a metallic earth. Such union, however, muſt alſo ariſe from the nature of the *ſulphur* itſelf, as ſhall be hereafter ſhewn from *compoſition*; where I have treated both iron and copper with *ſulphur*.

(2.) That ſulphur may be found, in a quite crude caſt-iron; for we need not prove, but certainly admit, from the hiſtory of the operation of *crude-ſmelting*, and alſo frequently in forged iron: but then this muſt be owing to an undue degree of ſcorification, and conſequently to the mineral *ſulphur* not being properly ſeparated, as the coarſe grain and brittleneſs of ſuch iron plainly ſhew: but, if you take a fine tough iron, or, which is better, a ſteel; muſt it not then be granted, that, if the *ſulphur* educed be not the common mineral, but a proper, metallic *ſulphur*, appertaining to the eſſence of the metal, it ſhould be found in all, even the beſt ſort, as a neceſſary conſtituent part: but, from the *ground-mixtion* and eſſence of iron, there is properly but one, not a two-fold ſort, and ſo far no ſulphur to be ſhewn from any one.

'Tis certain, we plainly obſerve in *caſt* and the like crude iron, ſulphur a conſtant companion, nor is it a ſtranger in *black-copper*. Now the queſtion is, whether it holds firmer and longer in the iron or the copper.

If we reflect, that the *pyrites mixtion* conſiſts in no ſuch compoſition as might be ſuppoſed to ariſe from the running together, in concocting and ſmelting

ing ſulphur, and a metal-earth, but in a production or generation, and thus in an internal ground-union, as has been often mentioned; where then ſuch accurate ſeparations, as that one part ſhall not either ſwallow up, force over with it, or keep back ſomething of the other, are neither credible nor poſſible, the caſe will prove eaſy. Again, let us conſider what a number of times copper muſt paſs thro' the fire, in roaſting and ſmelting, 'ere it only becomes *black-copper*, whereas iron-ſtone ſcarce wants a ſingle roaſting, being directly conveyed to the tall furnace.

(3.) Conſider only the violence of the degree of the fire in the tall furnace for iron, above that in the furnace for copper; ſo that, by the ſudden briſk flux, the ſulphur ſeparates not ſo accurately from the metal earth; but becomes, in ſome degree, incorporated with the metal; whereas, by a more gentle fire, it might more accurately and much ſooner be ſeparated than from the copper; as I obſerved from meaſuring the time for roaſting the proofs of copper ores and iron-ſtone: tho' there may be inſtances where the contrary may happen, and this may be owing to this or the other admixture; yet, it happening more rarely, we muſt abide by what more generally occurs.

Iron, in whatſoever manner treated, does not ſo readily as copper admit *ſulphur*. The moſt feaſible method I know of is, firſt, to ignite the metal well, and then convey the *ſulphur* upon it; when the copper actually mineraliſes, entirely loſes its colour and metalleity, turns of a grey caſt, almoſt like a fallow ore, and increaſes in weight about a fifth: whereas iron not only remains without the leaſt

leaſt increaſe, but alſo unaltered in colour and malleability, and therefore not the leaſt penetrated by the *ſulphur*. What unfits iron for receiving the *ſulphur*, is its eaſily burning away, and turning to an earth, ſooner than copper, whereby the due introduction of the *ſulphur* into it is prevented. 'Tis true, copper, by the art of ignition, becomes covered over with a kind of ruſt, or ſcales, which at length, are eat thro' or penetrated by the ſulphur; whereas iron will receive none of it, only ſuffering it to ſettle a little externally thereon, be the degree of fire as great again as for the copper, and thus be the ingreſs of the *ſulphur* facilitated as much as may be.

Here might be expected a fuller and more particular examination and deſcription of *ſulphur*, but as this would require a great deal of time and labour, beſides, not properly belonging to our preſent undertaking, where I enter not into a particular detail of the parts of the *pyrites*, I wave it. My deſign is the analyſis of the *pyrites*, not the hiſtory of each conſtituent part in particular; though, on the ſcore of inferences, connection, and other circumſtances, I could not always avoid the hinting at this, and ſome other matters, not immediately neceſſary to the knowledge of the *pyrites*.

A reader deſirous of ſomething peculiar, fundamental, and explicit on the head of *ſulphur*, may conſult Stahl, in his *Bedencken vom ſulphure*, his *Specimen Becherianum*, his *Menſis Julius de experimento novo verum ſulphur arte producendi*; where he will find full ſatisfaction.

There ſtill remains to be conſidered M. Homberg's relation, in the memoirs of the Royal Academy

demy of Sciences at Paris. Now, though Stahl, in his *Bedencken*, has made much mention of it to all uſeful purpoſes, yet, as I find this ſulphur-hiſtory to be ſtill very defective, being propoſed by this ingenious perſon only as an eſſay, it may not be improper, or unuſeful, to inſert here, at large, his whole relation (from which Stahl has only ſelected one ſingle part, or experiment) together with ſome remarks and experiments of my own; eſpecially as he brings many experiments, which deſerve a ſerious attention in the hiſtory of nature. His account is as follows, under the title of, *An eſſay on common ſulphur*.

'All thoſe matters called ſulphureous, are ſo 'entangled and blended with earthy, ſaline, and 'aqueous particles, as very rarely to deſerve the 'name of *ſulphur*; in chemiſtry uſually applied, 'without diſtinction, to the inflammable matters, 'as, common *ſulphur*, bitumen, oils, *&c.* Some-'times they are alſo conſidered as certain mat-'ters, eſpecially among minerals, in no manner 'inflammable, and muſt be called *ſulphur*, merely 'on account of their colour: ſo that we ſee this 'appellation applied to things of quite oppoſite 'natures, and men appear ſtill to have very con-'fuſed notions thereof, nay, to be almoſt quite 'ignorant of what *ſulphur* properly is. Now, *ſul-'phur* is one of the moſt conſiderable *principles* in 'chemiſtry.'

Here I would hope, that by the term *principle*, he means not a ſimple or original principle, as will appear from what follows.

'Wherefore as in this art it muſt be known, in or-'der to the forming a rational judgement of it, it ap-

'peared

'peared to me a matter of importance to examine 'its nature and characters, and learn to diſtinguiſh 'it from the other principles, *&c.*'

'Common *ſulphur* appears to me to have been 'compounded of ſeveral matters; as (1.) an 'earth, (2.) a ſalt, (3.) a fatty, inflammable 'matter, and (4.) ſome metal. The three firſt are, 'in weight or meaſure in it, in a proportion of 'equality, nearly, and almoſt conſtitute the whole 'maſs of the *ſulphur*; from which I premiſe, that 'by means of ſublimation, it is purified from its 'ſuperfluous earth, nothing of it remaining, but 'only ſo much as the fire could have carried up 'along with the other principles,' (rather, that nothing of it went over, but what the fire, *&c.*) 'the produce of this ſublimation we commonly 'call *flowers of* ſulphur. The metal, to be found 'in common *ſulphur*, is in ſo ſmall a proportion, 'that it may be overlooked.'

What is become of the water which he afterwards alledges as an eſſential part of the *ſulphur*, though from a falſe inference? How ſhall one, from pure refined *ſulphur*, which muſt be what is here meant, make out, and lay down for n° 1. a peculiar earth, that belongs neither to n° 3, nor n° 4, but may be diſtinguiſhed from both; ſeeing theſe two parts are very ſparingly, and the laſt, by his own conceſſion, almoſt undiſtinguiſhable therein?

'By a ſingle proceſs, the matters which make 'or conſtitute common *ſulphur*, are not readily 'ſeparable from each other, both on the ſcore 'of their cloſe connection, and on account of the 'great volatility of the inflammable, fatty matter

'of

'of the *ſulphur*, which almoſt always carries along 'with it the other three principles.

'In a cloſe fire, namely, in ſublimation and 'diſtillation, all the four parts of the *ſulphur* aſ-'cend and paſs over together, without undergo-'ing the leaſt degree of alteration in their *mix-'tion.*

'In an open fire they are alſo diſſipated toge-'ther, yet, in this operation there happens a ſe-'paration of the fatty principle, which ſeparates 'in the flame, from the ſaline; the ſaline unites 'with the moiſture of the air, and makes what we 'call *ſpirit of* ſulphur; by this means ſetting itſelf 'free from all inflammable fattineſs, ſo that no 'remains of it can be obſerved. This ſpirit of '*ſulphur* is only the acid ſalt of this mineral, and, 'in every reſpect, reſembles that from vitriol.'

''Tis difficult to aſcertain the quantity of this 'acid ſalt in common *ſulphur*; for, the operation 'whereby this ſalt is procured, is commonly per-'formed by the accenſion of the *ſulphur:* now as 'no accenſion can happen without a free acceſs of 'air, moſt of this acid of the *ſulphur* is diſſipated 'and loſt; we, however, ſometimes procure more, 'ſometimes leſs, in proportion both to the ſkill 'of the artiſt, and the quality of the air. I em-'ploy a peculiar method for the purpoſe, ſo as 'from a pound of flowers of *ſulphur*, to have ſome-'times an ounce, ſometimes an ounce and a half, 'as follows.

'I take the largeſt glaſs receiver I can get, and 'make a hole therein, between eight and ten 'inches broad; this glaſs I hang, like a bell, quite 'cloſe

'cloſe over an earthen pot, which, at the top, is 'about five or ſix inches in diameter; in this pot 'I previouſly melt between 10 or 12lb. of *ſul-* 'phur, 'till quite full thereof; then I ſet the *ſulphur* 'on fire, ſo as to burn all over its ſurface; after 'which I place the glaſs as cloſe to it as may be, 'without extinguiſhing the flame; the acid ſpirit 'trickles down into an earthen glazed veſſel, in 'which the pot, containing the burning *ſulphur*, 'ſtands upon an inverted diſh: in this method, 'which generally ſucceeds well, between five or 'ſix ounces of ſpirit of *ſulphur* may be procured 'in the ſpace of twenty four hours *.'

A like

* Mr. Seehl, in his paper, containing, An eaſy method of procuring the volatile acid of ſulphur, recommends the two following ways. Proceſs I. Take a pound of the flowers of brimſtone, and five pounds of dry fixed alcali ſalt, grind them together, and put the mixture into an iron pan; add, by degrees, a little water, ſo as juſt to diſſolve the fixed alcali; gradually diſpoſe the whole to boil, in order the better to diſſolve the ſulphur; when theſe have boiled for a quarter of an hour, add more water, by degrees, and when the ſulphur appears to be diſſolved, filtre the ſolution, evaporate it to perfect dryneſs in an iron pan, 'till it almoſt begins to melt; then take out the dry powder; when cool, put it into a tubulated retort, which being placed in a ſand-heat, and a receiver luted on, pour in at the tube, by degrees, two pounds of rectified oil of vitriol, and immediately ſecure the tube with a ſtopple of chalk, luted, and luting: then give a gradual fire for ſome hours, till the volatile ſpirit is come over; after which, let the fire go out, take off the receiver, and carefully pour the liquor into a glaſs phial, to be cloſely ſtopped with a glaſs ſtopper. The volatile ſpirit thus procured will be about twelve ounces in weight, and appear tolerably limpid, ſmell extremely quick, pungent, and *gaſſy*, or ſulphureous. Proceſs II. Take a pound of the flowers of brimſtone, four pounds and a half of fixed alcali ſalt, grind and mix them well together, put the powder into an iron pan, over the fire, add a little water, by degrees, to diſſolve the ſalt, then boil gently for a quarter of an hour, add more water, and afterwards three pounds of ſtrong quick-lime, let all boil together for a while; when the ſolution

is

A like contrivance we find in Lemery's *cours de Chymie*, and which Homberg, but with no ſmall degree of improvement, in regard to the bigneſs of the glaſs, (the former employing only a glaſs funnel) may have probably borrowed from him.

'This proceſs, 'tis true, coincides with the uſual 'method by *the bell*, but much altered and im-'proved, as by the former there is much more pro-'cured than by the latter method, which is princi-'pally owing to two improvements; the firſt, in 'the large receiver employed inſtead of the glaſs 'garden bell, which in circumference is much too 'wide, and in internal capacity much too ſmall 'and narrow, that but a little can ſettle thereon, 'when much muſt evaporate, and be quite loſt; 'whereas the fitted receiver has a ſmall aperture, 'and internally a large width, whereby the large 'evaporation is obviated, and a more abundant 'collection promoted. The other improvement 'regards the quantity of the *ſulphur*, there being 'formerly too little *ſulphur* put in at once, and 'that often ſcarce melted, conſequently, the acid 'not ſo capable of aſcending, eſpecially in ſuch 'quantity as one would willingly have it; which 'is ſo true, that when the pot holds not more 'than 10 or 12 lb. when not always full, and 'when the *ſulphur* is not thoroughly melted quite

is compleat, filtre the lixivium, and evaporate to a dry powder, as in the firſt proceſs; put this powder into a tubulated retort, and pour on, by degrees, a pound and half of rectified oil of vitriol; proceed to diſtill, as before; and thus you will obtain about eight ounces of a more ſtrong, and more volatile acid ſpirit than the former; of a yellowiſh colour.—Our author owns it was Dr. Stahl's method that gave him the hint of doing the ſame thing in a better manner.

'down to the bottom of the pot, the *ſulphur* gra-
'dually conſumes, and we can procure but little
'or nothing of the acid ſalt of the *ſulphur*.

'You muſt be careful to clear the upper ſurface
'of the burning *ſulphur* with an iron wire, or rod,
'as there ſettles on the top an earthy ſkin, which
'not only of itſelf gives no flame, but alſo quite
'ſmothers what does; this only holds good of that
'*ſulphur* which is whitiſh, blackiſh, or of a green-
'iſh caſt, a beautiful yellowiſh *ſulphur* being ſub-
'ject to no ſuch accident'.

Here M. Homberg takes notice of a difference between *ſulphurs*, as they happen to be crude and purified, the latter of which muſt be always of a beautiful citron-yellow, the former being generally of a greeniſh caſt, and ſometimes inclining to an orange colour, from its containing ſomething foreign, particularly arſenic, which belongs not at all to the nature of the *ſulphur*, and is ſeparable in the refining.

'Though this proceſs affords more of the acid
'ſpirit of *ſulphur* than the common method by
'the bell, yet ſtill much of it is loſt, as may be
'eaſily perceived by the ſtrong ſulphureous ſmell
'about the veſſels; ſo that hence we cannot learn
'what is its due quantity and proportion in the
'*ſulphur*.

'This acid ſpirit is entirely ſeparated from its
'inflammable fattineſs, and highly adapted to
'become a volatile, and almoſt inſipid ſalt, like
'the acid ſpirit of vitriol itſelf, which it greatly
'reſembles, nay, I might ſay, is one and the
'ſame with.'

What

What our author means by *the volatile and almoſt inſipid ſalt*, I cannot conceive; a volatile, namely, a ſpirit of vitriol, becoming *ſulphureous* by means of a fatty addition, I well know, and yet ſo inſipid is it, as to be corroſive. I have alſo a dry volatile acid ſalt, but powerfully corroſive with all manner of lixivious ſalts. Would we abſtract a ſpirit of vitriol over lixivious ſalts, and call what goes over (which is a pure phlegm, ſet free from its acid ſalt) an edulcorated ſpirit of vitriol, as ſome have fancied to themſelves, we might then indeed procure ſomething inſipid, but ſomething, at the ſame time, ſeparated, the acid of which was not edulcorated, but left behind in the alcali; and thus, neither a ſalt, much leſs a volatile ſalt, but a pure plain water.

'This then is one of the principles of the *ſulphur*, namely, its ſalt, looſened from its other principles, but mingled a-new with the univerſal receptacle of acid ſalts, namely, the moiſture of the air: the fatty, inflammable, as well as its other earths, are, by evaporation, loſt in the air.'

'By the following proceſs I have ſeparated the parts whereof common ſulphur conſiſts, ſo that each may be exhibited apart. Put into a body, or cucurbit of two meaſures, four ounces of flowers of *ſulphur* (or fine-rubbed *ſulphur*) pour thereon a pound of oil of fennel, or turpentine, let them ſtand together for eight days in ſtrong digeſtion, and the oil will diſſolve the *ſulphur*, and acquire a highly red colour; let them cool, and you will find the *ſulphur*, to the quantity of about three ounces, ſhot at the bottom into yel-

'low needles. Pour off what is ſtill fluid, ſave 'it, and pour on again a pound of oil, and ſet 'it again to digeſt, as before; when the veſſel is 'cold, pour off the fluid, and you will find the '*ſulphur* remarkably leſs in quantity: repeat this 'four or five times, 'till all the *ſulphur* is diſ-'ſolved. Put all theſe ſolutions together into a 'glaſs retort, (becauſe the matter is apt, in the 'end, to froth much) and diſtil for twelve or fif-'teen days and nights, by a very gentle fire, and 'there will come over about $\frac{2}{3}$ of the oil employed, 'colourleſs, and quite clear, and with it about 'four ounces of a whitiſh, ponderous, and vitri-'olic acid water, after this, red drops of oil: then 'apply another receiver, gradually increaſe the 'fire, and in ſeven or eight hours you will have 'forced off all you well can: inſtead of a receiver, 'you may employ a glaſs retort: moſt of the oil 'turns, at laſt, very thick and high-coloured, on 'which ſtill floats ſomething of a whitiſh, highly 'acid water: in the retort there remain betwen 2 'and 3 $\frac{1}{2}$ ounces of a black, ſpongy, ſhining, in-'ſipid matter, which will neither kindle, burn 'white, nor ſuffer any remarkable loſs in the 'fire.'

'Re-diſtill the matters found in the ſeveral re-'cipients in a very gentle fire, for ſome days and 'nights, in order further to ſeparate the remain-'ing oil from the acid water: upon the reſiduary, 'bituminous, black matter, pour half a pound 'of good ſpirits of wine, and diſtil very gently; 'pour again freſh ſpirits thereon, and repeat this 'ſo often, 'till what goes over carries along with 'it no more bad ſmell.'

'Theſe

'These diſtillations, performed with ſpirits of 'wine, carry with them, from the black bitu-'minous matter, thoſe parts of the *ſulphureous* 'acid, that would not come over at the firſt: 'now as the ſpirits may, together with the acid, 'diſcharge all the rank ſmell, which ſolutions of '*ſulphur* commonly have, ſo I am perſwaded, the 'acid of the *ſulphur* may be the cauſe of this into-'lerable ſtench:' (in part, indeed, not ſolely, but with the addition of a burning fattineſs.)

'Now, in order to gueſs at the quantity of the 'acid and ſalt procurable from four ounces of flow-'ers of *ſulphur*, I took two ounces of ſalt of tartar, 'well dried, and diſſolved in common water; I 'poured thereto all the whitiſh acid water, pro-'cured from the ſaid *ſulphur*; and, after efferve-'ſcence, evaporation, and drying, I obtained as 'much ſalt as came to above three drachms, ſix-'teen grains.'

Then, according to this proceſs and calculus nitherto, there are in four ounces of *ſulphur*, three drachms and ſixteen grains, provided M. Hom-berg has employed enough of the ſalt of tartar, and ſomething of the *ſulphur*-ſalt unentered into it, did not remain behind, as the alcali, employed for the purpoſe, appears to me to have been too little.

'The firſt remaining black matter I put into 'a crucible before the *blaſt*, and ignited it, when, 'indeed, it fumed a little, and ſmelt of burnt '*ſulphur*, alſo was encreaſed about two drachms, 'but found unchanged in the leaſt, either in co-'lour, taſte, or ſponginеſs.

'I afterwards placed it in the focus of a burning-glaſs, but could neither make it take fire, nor melt it; only it boiled, and gave forth a ſmell of *aqua fortis:* after leaving it in the fire ſo long, 'till it fumed no more, I found it decreaſed almoſt an half, and what remained appeared black, ſhining, flaky, inſipid, and in no manner altered by the burning-glaſs.' (This is, certainly, a circumſtance that merits great notice, in particular, that it ſhould refuſe to yield to one of the moſt quick and violent fires of vitrification in nature, namely, that of the ſun.)

'Now, this matter I ſuppoſe to be the earthy part of common *ſulphur.* I weighed it, and found it to be one ounce, and almoſt one drachm, that is, about $\frac{1}{4}$ of the whole:' (that is, of four ounces of *ſulphur.*)

'Now, as I could not force it by the burning-glaſs alone, and *per ſe*; upon adding a little borax, it melted to a glaſs of a grey-brown colour: this glaſs, after ſtanding for ſome time in a moiſt place, I found, at laſt, ſtrike a grey-green efflorescence all around; whence I learn, the *ſulphur* employed in this proceſs, to have held ſome copper, but in ſo ſmall a quantity, as to be inſeparable from it in a metallic form.'

'The fume ſtill forced out by the burning glaſs, is, in all appearance, the remains of the fatty earth and acid ſalt of common *ſulphur*, which the common fire could not force out. I apprehend this fume to have contained as much oily matter as acid ſalt; conſequently, in this *caput mortuum*, to be about three drachms of ſalt more, which,

'with

'with the three drachms and ſixteen grains above, 'make ſix drachms, that is, $\frac{1}{6}$ in four ounces of 'flowers of *ſulphur*, &c.'

This account our author [M. Homberg] has ſpun out to a ſtill greater length; but as what remains behind does not relate to the hiſtory, but his reflections and thoughts thereon, I ſhall only extract a couple of articles from it, and illuſtrate theſe, and ſome of the foregoing, with ſome remarks.

In the firſt place, 'tis not the true method of analyſing a ſubject into its eſſential parts, to make uſe of *additions*, that may afford any ſuſpicion of cloſer mixtions, and new inſeparable eductions. *Sulphur* and oil are ſo nearly allied to each other, that nothing can be more ſo. What can we ſuppoſe to be in oil, proper for making ſeparations? And how indifferently too does the ſeparation come out, eſpecially when we conſider the remaining black, unvitrifiable earth?

(2.) Is it alſo certain, that the aſſigned ſixth part of acid ſalt was all of it derived only from the ſulphur; and may not the vegetable acid, ſuch as may be plainly ſhewn to be in oils, contribute ſomething alſo, and how much?

(3.) The three laſt drachms, ſeparated from the remainder by the burning-glaſs, our author only ſuſpects to be an acid ſalt of *ſulphur*, he cannot prove it, like that gone over in the diſtillation.

(4.) Doubtleſs, the oil has alſo left behind it not a little of a coaly earth; how then can all the matter remaining over be aſcribed to the *ſulphur*?

Nay, how can the half, or a fourth only; ſeeing oils *per ſe* contain not a little earth, and more than a little oil was employed in this proceſs; on the contrary, the *ſulphur* conſiſts leaſt of all in an earth, but almoſt entirely in the acid ſalt?

(5.) Are all greens the effect of a copper? Does not alcali with acid, alſo with *ſulphur*, make a green? Though I allow *ſulphur* a copper-earth, which is only to be ſhewn with ſal-ammoniac, or ſpirit of urine.

(6.) Has he ſufficiently reflected, when he expreſſes his ſurprize at the quantity of the water gone over, and which he might alſo have eaſily ſuppoſed in oils, that in the explicit enumeration he above makes of the principles of the *ſulphur*, he has there left it quite out, and would here reckon it for one? For the reſt, this experiment is ſo far ingenious, that not only a large quantity of acid ſalt is educed, but an extraordinary proportion to its quantity in the *ſulphur*; and it is no ſmall commendation to M. Homberg, that he has ſhewn ſo much diligence in the examination of natural bodies, and diſcovered ſuch a number of truths, that we ſcarce find many to have equalled him in this reſpect.

CHAP.

CHAP. X.

Of the ARSENIC in the PYRITES.

WE are here diſtinctly and orderly to ſhew, whence *arſenic* proceeds, what it is, and what analogy it bears to other bodies; it being a dangerous ſubject, few are very fond of entering into an intimate familiarity with it; for which reaſon, it is a matter hitherto but little underſtood.

Arſenic, in its proper, entire form and colour, greatly reſembles a white metal, nay, almoſt its own ore, *miſſpickel*, alſo *cobald*; but in its texture, its relation to the fire, air, and hammer, we ſoon find it differ conſiderably from the nature of genuine metals, nay, ſomething from that of the ſemi-metals: and I know not whether I ſhould allow it to have ſomething more, or ſomething leſs than theſe.

In itſelf it melts in the fire, not as a metal uſually does; nay, not even as a biſmuth or regulus, unleſs ſomething fixing, as iron, be added to it, without which it begins directly to fume, and ſo flies entirely off. Thus it is fugitive; but in cloſe veſſels returns again to its priſtine metallic form; nay, though *regulated* by means of iron, not a little of which goes to make up the regulus, yet, by a gentle roaſting, it not only ſeparates again from the iron, but, by ſublimation, recovers its former ſtate. Under the hammer it manifeſts a great degree

degree of brittleneſs, and hence evidently appears to want a principal characteriſtic of a genuine metal; nay, it is not, like zink, ſemi-malleable, but quite brittle, like a biſmuth and regulus.

In the air it becomes black all over externally, whereas freſh out of the retort, at leaſt for the moſt part, it is of a ſhining bright, like a mirror; and each freſh fragment or ſhiver of it, broken in the morning, has a black ſkin upon it by night; ſo conſiderable is the ingreſs of the air into this, that the like is not known in any other metalliform body, either biſmuth, or regulus. It is further remarkable, that ſome genuine, though imperfect metals, as iron, copper, and lead, are more obnoxious to the action of the air than theſe laſt, as appears by the ruſt, verdigreaſe, and ceruſe, they ſeverally yield. In a word, *arſenic*, in its genuine form, is a ſemi-metal, a middle metal, and a fugitive metal.

But *arſenic* is, in this ſemi-metallic form, leaſt of all known, appearing not ſo often therein, as in other forms; and thus I am obliged to deſcribe it in every diſguiſe it wears, both as exhibited by nature, and the various proceſſes of art.

Arſenic appears either in a reguline, a powdery, or a glaſſy form; or as mineraliſed, or reduced to an ore-ſtate, a *ſlaggey* and ſtoney body. In a reguline form, it is found either ſublimed, and forced off, or as if caſt in a cone, like glaſs of antimony.

Of the ſublimed I have ſpoken above, and muſt ſtill add; firſt, that thus it is extreamly flakey, light, and porous, and unlike any other ſmelted reguline

reguline body; again, that it then diſcovers ſomething very peculiar, and worth noticing, particularly, its eaſy receptivity of the action of the air, and of the ſmutting or blackneſs thence ariſing, which is obſervable of no other metallic body whatever. Moreover, from this ſmutting by the air, we may probably infer, if not the formal preſence, yet the production of the fatty, inflammable matter; ſince this blackneſs is equally as fuliginous, or ſooty, as that generally in the ſublimation from the *white pyrites*, preceding, and ſometimes partly accompanying this volatile *arſenic* regulus; yet there to be conſidered, not ſo much a part of the regulus, as of the *pyrites*. Now, whether this ſmut or blackneſs be an actual ſulphur, and thus not its inflammable part alone, is not ſo eaſy to determine, as it cannot be ſeparated, and brought to any teſt; yet the firſt is the more probable opinion.

As (1.) the fuliginous form ſhews, if not a total reſolution, yet a ſuperficial corroſion, rather than a new production; and yet this laſt ſhould here ſeem to be the caſe, as neither in the ſubject alone, the *arſenic*, nor in the agent alone, the *air*, a genuine formal ſulphur can be exhibited: and further, as white *arſenic* itſelf may, by the addition of only an inflammable, not a ſulphureous matter, become, after a new ſublimation, ſmutted again. Now, in this form *arſenic* is denominated *fly-ſtone*, *fly-poiſon*; in regard flies, and the like inſects, are by its means deſtroyed; though the above black powder be fitter for the purpoſe, as, on the ſcore of its tenderneſs and poroſity, it is more communicable of its virtue to the water tempered therewith: and the appellation, *ſtone*, has been borrowed from the foſſil, or native *fly-ſtone*, which is a real

a real ſtone, or ore, and put to the like uſe; tho' the ſublimed neither ſhews like, nor contains any thing referable to the nature of a ſtone. And here the difference between native and factitious *fly-ſtone* is carefully to be obſerved, which you have, when the experiments exhibited therewith happen not to coincide; in regard the native, on the ſcore of its incidental admixture, proves, at times, to be ſomething different.

In a powdery form *arſenic* is of ſuch a degree of tenderneſs, or ſubtlety, as therein not to be exceeded by the moſt impalpable powders; and of different colours, as, black, yellowiſh, grey, and white; yet, moſt frequently, of the white grey. When it appears white, like a beautiful meal, or flour, which happens to it in the fining, it proves right pure; and by how much the whiter, ſo much the leſs is it ſullied with foreign admixture; if grey, it contains ſomething of a ſooty, inflammable, nay, a metallic earth; as appears from the grey *poiſon-meal*, often collected from the vents of the *tall furnace*, with ſome lead, and a little ſilver amongſt it; if black, it contains ſtill more of ſuch a coaly earth, to which colour it never arrives in a large and open, but only in a cloſe, ſmall, and ſudden or briſk fire; if yellowiſh, which colour commonly runs to an orange, it has then ſome ſulphur along with it.

Theſe various incidental colours proceed chiefly from the incidental ores along with it, as well in regard to theſe ores themſelves, as their various admixtures, which may be either accidental, or procured by deſign: where, for inſtance, the ſulphur, when lodged in an ore, and riſing together with the arſenic, muſt needs make it of an orange

orange colour. Yet, the kind of the fire and furnace, where the ore comes to be treated, is, in this caſe, certainly, of great conſequence, not only as to the production of the ſeveral colours of the *arſenic-meal* (the ſooty matter either burning away and diſſipating, or remaining therewith; the ſulphur either ſoftly retiring apart, or being hurried or laid hold of by the *arſenic*) but alſo as to the corporal form, in which it appears: for inſtance, the *poiſon-pyrites* yields, indeed, in the open air, a mealy, commonly a grey powdery *arſenic*, but in cloſe veſſels appears of a flakey, reguline form. Thus, it is one thing to *drive* or force it off in retorts, ſubliming veſſels, and the like, where the ore is out of the contact of the fire, and where the *arſenic* acquires its proper reguline form; another thing, to force it off in *roaſting furnaces*, as is done at the cobald and tin huts, on occaſion of roaſting the cobald and tin ores, where, by means of the adjoining wind-furnace, the actual flame, and fatty particles of the fire, play over and through the ore. The caſe proves yet different in ſmelting furnaces, where not only the flame of the coals, but alſo the fatty, and at laſt the alcaliſed coals themſelves, exert their efficacy on the ore; beſides, the force of the blaſt volatiliſing and carrying off along with the *arſenic*, not only crude earthy particles out of the ore, brought to the higheſt degree of activity by the ſtrong glow, but alſo metallic particles themſelves, as coppery, leady, and ſilvery. Laſtly, there is a further difference in open roaſting hearths, where the ore is not only expoſed to the immediate contact of the flame and coals, but to the actual influx of the air, weather, and rain; whence we are enabled to obſerve in fume-powders, that variety of colours, as, white, grey, and yellow, which, under covered and cloſe furnaces, does not ſo eaſily happen.

Now

Now where it cannot thus, on account of the reaſons mentioned, arrive to its proper ſemi-metallic form, but, according to the particular method of operation, happens to be diſperſed, it proves no other than an earth, an aſh, or a calx of a metallic body, whoſe metalleity may be deſtroyed, and again reſtored.

Thus it riſes in the operation of roaſting in the tall furnaces, and copper-furnaces, and ſettles whereſoever it finds the firſt cool and quiet retreat; in the tall furnaces, indeed, it ſeeks the higheſt; and where the air has once taken due hold of it, it is thereby diſſipated to a conſiderable diſtance; and this, at the mines and huts, is called *hut-fume*; however, this, which is a pure arſenic meal, is not to be confounded with calamy, though they are not unlike in colour; but the former ſettles lower down, whereas the other is by the fire driven much higher up.

Arſenic alſo lodges in zink and calamy flowers, in ſublimates and *cadmia fornacum*, though in a very ſmall quantity: theſe are either entirely powdery, or in tolerably compact lumps and maſſes, neither firm nor hard, but tender and crumbly, and eaſily pulverable, though in themſelves not a powder, but naturally like a baked earth. Their colour is commonly a dark-grey underneath, over that a whitiſh grey, and the uppermoſt of all a yellowiſh white; their particles are generally quite clear, or flakey, like a tender *glimmer*; their texture very porous, ſpongey, and looſe, conſequently are extreamly light; to the touch they feel rough, ſtubborn, and gritty, though rubbed to a tolerably fine powder.

They

They are generally, though falſely, conſidered as a proper *but-fume*, or *arſenic*, eſpecially when they aſſume appearances of a grey meal: but, not to inſiſt that experience ſhews quite the contrary, we may eaſily imagine, volatile matters, that ſhould ſtand and hold out, when ſettled in the confines of the ſtrongeſt glow of a furnace, to be ſomething elſe than *arſenical*; and hence we need not wonder, they deſtroy neither mice, nor rats.

This zinky matter manifeſts itſelf in tall ſmelting furnaces, particularly in thoſe where the operation of *crude ſmelting* is performed; that is, where ſmall or poor ores, which are commonly quartzy, mock-leady, and *pyrity*, alſo, incidentally, ſomewhat *glittery*, are ſmelted and concentrated from a large quantity of ore, to a regulus, or cake. It takes its place in the lower parts of the furnace, particularly on the ſides, having under it, for its ſtool, that mock-leady, ſtoney, and hard matter, of which hereafter.

b The manner of its origination muſt, doubtleſs, be like that of *arſenic*, namely, in the way of a fume and vapour, ſeeing no part of it is obſerved to be run. When expoſed long to the air and weather, it opens, that is, becomes tender and porous, and fit for making braſs; the reaſons of which are not proper here to be given, as I now only conſider it on account of its *arſenic*. At our huts it is thrown away, and as it muſt be knocked and broke off the furnace, 'tis called *furnace-fragments*, by many *calamy*, though improperly, on account of its very different admixture; wherefore that appellation ought to be qualified by the epithet *calamy-furnace-fragment*, or *furnace-calamy*; nay, it ſhould juſtly be

be limited, eſpecially if we would not confound it with that I am now to ſpeak of, and from which it differs not a little. But, as is already ſaid, it contains the leaſt *arſenic* poſſible, diſcoverable upon roaſting it, rather by the noſe than by the eye; but it partakes of ſulphur in a greater proportion, as appears alſo from the roaſting, and as may eaſily be conjectured from the ground-mixtion of this zinky matter. In a word, it ſmells partly *arſenical*, partly ſulphureous; as ſulphur may, intangled in ſuch calamy admixtures, reſiſt the hotteſt glow, ſo much more may *arſenic*, which commonly yields not ſo eaſily to the fire as ſulphur does.

Underneath, and behind this, there lies, lower on the ſides of the furnace, a ſtoney, hard, heavy, black matter, not properly to be claſſed for its *arſenic*, but rather, on account of its order of place. Many a one might take it for a ſlag, or ſcoria, than which it is nothing leſs, as appears upon breaking it; ſeeing it does not appear glaſſy, ſmooth, and ſhining, as genuine ſlag does. Externally this matter is often, as it were, glazed over, but internally has a quite different appearance, namely, that, notwithſtanding its hardneſs, which indeed, in reſpect of the abovementioned calamy-furnace-fragment, is conſiderable, yet it may be ground ſmall, ſo as to become like a ſooty duſt to ſmut the hands, which ſlag never does, unleſs reduced, in the moſt careful manner, to the fineſt meal. Here and there, internally, it alſo often appears *ſlaggy*, and run; nor can it be otherwiſe, conſidering the ſtoney nature of the ores employed in the crude-ſmelting, and the fierceneſs of the fire. This effete matter contains but little *arſenic*; but taking of what is glittering, and in texture often

often appearing like a fine-grained mock-lead, we ſhall find reaſon to claſs it amongſt arſenics; nay, ſometimes it ſhews ſo like a foſſile mock-lead, and a mineraliſed body, as to impoſe on the moſt intelligent in ores. The origination of this, indeed, rather than of the preceding *calamy* matter, ſeems to be owing to a caking or running together; yet it is alſo of various ſorts, and, upon properly viewing many a ſample of it, we muſt allow it rather to be aggregated together in the way of a damp, or vapour. For, though we find amongſt it pieces, not only caked together, but quite vitrified, as may be eaſily conjectured from the running together of quartzy, eſpecially if ſomewhat leady, and thus poſſeſſed of vitrifying particles, yet the principal part is of quite another, or rather a new appearance.

It appears black and grey, flakey, and almoſt like a mock-lead, though very different, it being more kindly and light. It is not only, in ſome meaſure, of the nature of zink, or calamy, which cannot be ſaid of any one ſort of mock-lead, but contains as much, if not more *arſenic* than the meagre, lean mock lead. In a word, 'tis a kind of fly-ſtone ſublimate, riſing up entirely at the laſt, but to no very great height; which, together with its calamy and *arſenical*, or, volatile portion, has taken along with it, by the violence of the fire, ſomething of a crude, earthy, and, perhaps alſo, of a mock-leady nature, whence it happens to conſiſt of ſo coarſe a mixture, as to be uncapable of mounting high; and this is ſimply called *furnace-fragment*, as it muſt be broke off, in order to clear and fit the furnace for a new operation; a name which may ſufficiently diſtinguiſh it from the abovementioned grey, white, yellowiſh

matter, if, for the greater perſpicuity ſtill, be added the epithets, *coarſe*, *mock-leady*, and *poor*.

Now in ſmelting-furnaces, where the *arſenical* matter ſkims off, or rather evaporates from the metal deſigned to be procured, I know of nothing elſe, which, as an *arſenic* form, ſhould here deſerve a place; all to be found there, and referable hither, being either *poiſon-meal* and *hut-fume*, or *poiſon-ſtone*, that is, *furnace-fragment*. For the external images appearing in many places in cluſters, or flakes, and the like beautiful conſections on this and the other *furnace-fragment*, according to the deſcriptions of the ancients, and bare copyings of the moderns, are very rare with us at Friberg, nay, they are not at all obſervable, and are, properly, ſomething procurable rather from actual calamy-works, than from ore-ſmeltings, ſeeing they appear in all manner of zinky flowers, and the like efflorescences, in the courſe of braſs-making.

We are not, however, to ſuppoſe arſenic, like ſulphur, to be entirely diſſipated in roaſting-hearths, and in furnaces, for more than a little of it fluxes in a metallic form along with any thing capable of retaining it; ſettling together with the metal, as in a regulus, in the fore hearth; bearing the being tapped off therewith; not mingling, 'tis true, with the metal, but parting from it, floating a-top, and bearing, after cooling a little, to be heaved off from it, like a cake. Yet, in the method of crude-working we obſerve, that what of it remains unvolatiliſed, goes into that regulus uſually called *crude-ſtone*, without being able to appear in the above ſeparated form; becauſe the metal, whether lead or copper, which ſhould, and does repel it, is not yet arrived to its due metallic body, but is ſtill greatly

greatly intermixed with all manner of earthy foreign matters, conſequently, is of a very looſe, ſpongey texture, and hence as light, if not lighter, than arſenic itſelf; and that matter, wherein it principally fixes, not yet ſeparated from the ſaid metals.

But in the methods of *lead-working* and *black-copper-making*, it plainly appears in our ſmeltings, where *arſenical* ores come into the *additions*, and where *arſenic-pyrites* happen in the *crude-working*, and the *crude-ſtone* being, at length, duly prepared, comes into the *lead-working*, and where the copper-ſtone being *ſet*, or drawn off, comes into the copper-working; nay, is there the whole, or principal part, when the lead-working happens to employ no pure *glitter*, or lead-ore, but is intermixed with all manner of rich, chiefly *arſenical*, ores, alſo with actual unſeparable cobaldiſh ores: in a word, where many ſorts come together, and one working ſucceeds another, 'tis no wonder, if, in many places, little or no mention be found made of *ſpeiſe*, *leg* *, &c.

What thus retains the *arſenic* to itſelf, and, in ſome meaſure at leaſt, fixes it, ſo as to make it flow like a metal, and bear the being caſt, is, principally, an iron-earth. I ſay *principally*, and this not only at our lead, but at our black-copper-workings; though particularly in theſe laſt, ſome admixture of copper muſt be allowed, and this, ſometimes, is called *ſpeiſe*, eſpecially, when produced from the lead-working; ſometimes *leg*, alſo *kupfer-leg*, when from the copper-working; it floating

* Theſe are the ſeveral appellations of the abovementioned floating *arſenical* regulus.

and lying a-top the tapped black-copper, and from white inclining a ſmall matter to a copper reddiſh caſt. Both are of a whitiſh metallic appearance, texture, and weight, but brittle; moreover, tolerably hard, according as they are more or leſs incorporated with metallic earth; both contain from a third to a half of *arſenic*, and, as I have experienced myſelf, may alſo hold a good deal more, but ſeldom leſs; and that from incidental circumſtances, which, in the buſineſs of ſmelting, both in regard to the method of working, and to the matters themſelves, may be endleſsly variable.

Speiſe is a term uſed alſo among workers in braſs, but with the addition *glocken*, thus denoting bell-metal; a matter appearing pretty pale, though inclining more to a yellowiſh caſt, as it muſt, on account of its principal ingredient, the braſs: as to the reſt, it is harder, and more metallic than, and therefore not to be confounded with, our *but-ſpeiſe*. Aſſayers alſo have their *ſpeiſe*, but which they might more properly call an iron-regulus; as yielded by thoſe *pyrites* which contain no copper, and remains further unexamined by them, ſeeing they look for nothing elſe in *pyrites*, but ſilver and copper, conſequently is unknown to, and thrown away by them, under an appellation borrowed from ſome colour or other, and which, in ſome meaſure, ſerves as a ſcreen for their ignorance. Now, 'tis true, there are ſome *pyrites*, whoſe iron-earth is *arſenicated*, as the white, entirely; many of the yellowiſh, conſiderably; and thus, in aſſaying, there ariſe ſuch *reguli*, as aſſayers may, on the ſame foot with ſmelters, call *ſpeiſe*; but as ſome of them afford only a very ſmall matter of, or no arſenic at all, 'tis wrong to bring them under one common appellation, *ſpeiſe*.

In

In the *arſenic-huts*, which are chambers where the *arſenic* is refined and purified, *arſenic* again exhibits the appearance of a fine meal, or of a cryſtalline body; both ways, ſometimes of a white, ſometimes of a yellow, ſometimes of an orange caſt: yet it ought not to be diſtinguiſhed ſo much by being a meal, or powder, and a fluxed body, as by the variety of its colours; for the powder is convertible to a cryſtalline body, and this laſt may be reduced again by a heedful ſublimation, to a meal, and the meal again converted to fly-ſtone. Now, as the meal, either yellow or white, turns moſtly, nay, wholly to a cryſtalline body, we ſhall here the rather treat of the cryſtalline form of *arſenic*; and as the yellow and orange colours remarkably differ from the white, we muſt ſay ſomething to three ſorts of *arſenics*, namely, *white*, *yellow*, and *red*.

Arſenicum cryſtallinum album, white cryſtalline *arſenic*, is a white, conſiderably ponderous, fluxed, glaſſy, tranſparent body, brought to that form by means of pot-aſh and ſublimation. The pot-aſh principally ſerves for purifying, or for, at leaſt, retaining and conſuming that fuliginous matter lodged in the *arſenic*, and which makes it of a greyiſh caſt; be ſuch matter only from an inflammable earth, or, as it alſo ſometimes happens, from ſulphur itſelf. Whether it have any other effect thereon, muſt be learned from a careful examination, made expreſsly, both of this cryſtalline *arſenic*, and the crude *arſenic-meal*, and from a candid compariſon of the ſeveral proofs made, the ſeparate conſideration of which would here carry me too far.

In order, however, to diſcover the genuine proper nature of this ſmutting ſubſtance, I have, as ſuppoſing it to be a fat, inflammable earth, digeſted the white cryſtalline *arſenic*, after rubbing it fine, along with inflammable matters, as expreſſed oil of almonds, and by ſublimation procured a quite dark-grey ſublimate. Again, treating it in the ſame manner with iron-filings, by this means, along with ſome white cryſtalline flowers, I have obtained a dark-grey *arſenic*; ſo that the black matter ariſing along with the *arſenic* from *arſenical pyrites*, is to be aſcribed to an iron-earth; eſpecially as it is otherwiſe evident, that no *arſenical pyrites* is without it.

I alſo found quickſilver alone capable of withholding this blackneſs, and alſo the yellowneſs of yellow *arſenic*, and of raiſing the *arſenic* alone in beautiful white cryſtals; a circumſtance, ſure, worth no ſmall degree of attention. It is pretty heavy, nay, to a degree of making it ſuſpected of containing ſomething metallic, even ſhould it be unknown in its native form; it is partly tranſparent as glaſs, partly of a milky colour; and what was tranſparent, in time, loſes that quality, becoming externally, alſo, of a milky colour, particularly by means of the free acceſs of the moiſt air; nevertheleſs, it continues ſparkling or ſhining, and, againſt the light, if newly broke, with its ſhivers, appears ſmooth, and internally tranſparent; but, by degrees, it loſes all its tranſparency, and that ſooner or later, according to the ſize of the pieces or ſhivers, and the nature of the place they are in; 'till at laſt, ſtill retaining its ſplendor, and without falling, or turning to a powder, it becomes throughout of as milky a colour

lour as a white ſmalt, uſually employed in enamelling; and, to my mind, almoſt ſuch another maſs as that ariſing from running alum and common ſalt together, for the preparation of Glauber's ſalt.

Whether it be a real ſalt, I ſhall as little diſpute as believe, ſeeing it does not partake of the genuine properties of a ſalt, being neither ſoluble in water, nor peculiarly affecting the tongue: the trueſt conception we can form thereof, conſiſts in conſidering it a calcined metallic body; as, in its origin, it exhibits a metallic body, which is here only a little diſguiſed, but again recoverable upon the addition of the metallic portion, which happened to be burnt out. In the courſe of the refining, it riſes like a white fume, and ſettles, at firſt, as a white powder, which, as the heat gradually encreaſes, 'till the ſubliming veſſel be made of a thorough glow, cakes and runs to a cloſe, glaſſy body.

Arſenicum *cryſtallinum flavum*, yellow cryſtalline *arſenic*, is, in its principles, nothing elſe but the above white ſort, and in the very ſame manner brought to that form; only that ſome ſulphur happens to ſtain its beautiful milky colour with a caſt of yellow; and though, properly, not ſo tranſparent as a freſh white ſort, yet, in its ſubſtance, it is ſhining and glaſſy, like a yellow ſmalt, or enamel, though by far more beautiful.

Arſenicum *rubrum*, red *arſenic*, differs from the yellow only in being more richly doſed with ſulphur, and, conſequently, has a greater degree of opacity, and a leſs glaſſy appearance; for the reſt, 'tis an *arſenic* in ground, and popularly called *ſandarach*;

darach; yet, under a proper encheireſis, or treatment, it often turns out as beautifully tranſparent as any ruby, only its redneſs inclines more to an orange, whence it is ſometimes called *ſulphur-ruby* *. If it degenerates to a brown-red, it has either ſtood too long in the fire, or got ſome foreign admixture along with it, either by accident, or with deſign, as may be ſeen from the *lapis de tribus*, where the metallic, antimonial portion muſt needs ſully it; yet this brown-red tint is often no impediment to its tranſparency, when held to the light in thin pieces.

It is brought over, like ſulphur, by a diſtillation, from retorts into receivers, rather than by a ſublimation, and this is the very reaſon of its opacity; for, if you force off only a little of it again in a glaſs body by a ſtrong ſand-heat, ſo as to melt in the neck, it runs down in clear drops, appearing like a red glaſs. It is certain, *arſenic* greatly affects the ſulphur found here, and muſt therefore impart the colour; and no way has hitherto been hit on, I will not ſay, of ſeparating it entirely, which is impoſſible, but of ſeparating even the greateſt part of it; and yet ſome of it muſt go off, partly of itſelf, by the ſofteſt degree of fire, for ſulphur mounts eaſier than *arſenic*, though this ſucceeds not with the yellow cryſtalline *arſenic*; partly through the addition of a ſeparating medium, or matter, which ſulphur more affects, for inſtance, quickſilver: when the *arſenic* happens to riſe white ſeparately, and ſettle higher up, the quickſilver, which cannot riſe ſo high, ſettling lower down, as a grey ſublimate along with the ſulphur.

More-

* Rubinus ſulphuris, item, rubinus arſenici.

Moreover, as ſulphur appropriates the quickſilver to itſelf, and quits the *arſenic*, ſo it keeps in a juſter proportion with the former, than with the latter; it, in one caſe, bearing more and leſs, almoſt in the proportion of the doſe given, whatever that be; and in the other, being incapable of receiving either more or leſs, the proportion being conſtant, a circumſtance worthy of notice.

Red *arſenic*, or *ſandarach*, may be made from pure ore, and ſuch *pyrites* alone, wherein the ſulphur and arſenic are together in a ſufficient quantity; or from *pyrites-additions*, or doſings, ſo that the one ſhall ſupply what the other wants; or from poiſon-meal and *ſulphur-pyrites*; or from *arſenic-pyrites* and ſulphur-ſlags, that is, the *arſenical* ſulphureous reſidue procured from crude ſulphur: but the attempting to make it from white cryſtalline *arſenic* and actual ſulphur, either does not ſucceed at all, or with great difficulty: whence appears, (1.) the ſomewhat coy or repelling nature of the white cryſtalline *arſenic*; (2.) how much the chemical combinations depend on the appropriations, congruencies, or aptitudes, alſo on the diverſity of the matters, when employed in their unprepared and native ſtate, directly from their matrices and natural admixtures; ſo that red *arſenic* is not a thing, in its ground-ſubſtance or principles, diſtinguiſhable from the white, as ſome falſely imagine.

Thus we have exhibited *arſenic* in all its various appearances, from its firſt fly-ſtone ſtate, to that wherein 'tis fitted for common uſe, and thus from the huts to the ſhops: and not only ſo, but we here teach how to reduce it back again to all the forms it had before undergone; in particular, to its

firſt,

firſt, native, reguline, ſemi-metallic ſtate, ſo as to prove more beautiful than it originally was; as thus: take finely pounded white cryſtalline *arſenic*, and mix it, either with the black flux, or with ſalt-petre and tartar, in the uſual manner of making regulus of antimony, and letting it duly run in the wind-furnace, you then procure a compleat, beautiful regulus of *arſenic*; yet, little or none at all, if either you let the crucible ſtand too long, or give too briſk a fire: but if you miſcarry in this, take iron in aid, and proceed in the uſual method of preparing the martial regulus of antimony, and the *arſenic* will be ſufficiently fixed. Only, by this laſt method it proves impure, from having ſwallowed up a great deal of iron, as appears from the analyſis; it is, however, the greateſt part *arſenic*, which may eaſily again be made to fume from it. It generally appears like a *ſpeiſe*, with which it alſo greatly agrees, and, upon adding ſome copper to it, it turns of a reddiſh caſt, nay, becomes the very *mixtion* of the above deſcribed *kupffer-leg*, nay, even *kupffer-nickel*.

I ſhall further only ſuggeſt, that *hut-fume* corrodes the very window-panes of the huts, turning them of a milk-colour, and rendering them dim and opake, and thus it finds, as it were, a magnet in them. Again, that with lead it vitrifies exceedingly eaſy; and the glaſs thus procured proves extremely uſeful in *incoctions*, as it forces ſtubborn and unkindly ores, with this circumſtance attending, that this higheſt of combinations, which is even performable in cloſe veſſels, is an uncommon and almoſt incredible inſtance in the buſineſs of vitrification: and this, in my opinion, affords, if not the principal, yet not the leaſt conſiderable reaſon, why *miſſpickel*, when its *arſenic*, in the operation of

crude-

crude-working, happens to corrode, vitrify, and thus eaſily carry off the lead among the ſcoriæ, at leaſt from the *glitter*-eyes always intermixed, is conſidered as rapacious and unkindly.

To recapitulate briefly; *arſenic*, by means of art, ſhews itſelf either a volatile, flakey, ſemi-metallic, or a reguline body, which is a factitious *fly-ſtone*; or a grey, white, and yellow powder, and then it is called *hut-fume*; or a *furnace-fragment* (cadmia fornacum); or a *ſpeiſe*, or a kind of glaſſy body, and then 'tis a white and yellow cryſtalline *arſenic*; or a red *arſenic*, that is, *ſandarach*; or again, a ſemi-metal, and a regulus.

Here I muſt not omit explicitly mentioning a matter I only incidentally touched on above, as being, in ſome caſes, entangled with *arſenic*, and this is *zink*, which lodges both in foſſile and factitious calamy.

Zink, or *ſpelter*, cannot better be deſcribed or conceived than by ſaying, that it is that matter which makes or tinges copper yellow, an effect to be affirmed of no other thing in nature beſides. *Zink*, ſo far as is hitherto known, is, principally, in three forms; (1.) in that ſemi-metallic, reguline form, properly called *zink*, or *ſpelter*; (2.) in an earthy, or rather ſtoney form, namely, in the foſſile calamy, or *lapis calaminaris*; (3.) in flowers and ſublimates, in particular, in the above deſcribed white-yellowiſh tender *furnace-fragments*. Genuine formal *zink*, alſo called *contrefait*, is a ſemi-metal, externally like lead, yet ſomething brighter, internally ſhining like a mirror; not very brittle, like a biſmuth or regulus, and yet not very malleable; altogether as inflammable as a ſulphur, when it changes

changes to a white ſpongy froth and wool, a *philoſophical cotton.*

It turns copper not only of a higher yellow, whence the metal happens to be diſtinguiſhed by the appellation, *prince's-metal*, or rather *bronze-metal*, at leaſt with us Germans, but it alſo renders it more brittle than the foſſil calamy does; hence, I ſuppoſe the proper tinging ſubſtance, which in the foſſile calamy is blended with an earth, ſomething adventitious and foreign, not entering along with the tinging parts into the body of the metal, is incorporated in another metallic brittle-making ſubſtance, namely, lead.

For, (1.) the ſort of ore at the Hartz, whence our *zink* is derived, is never without lead-ore, nay, is principally found to conſiſt therein; (2.) from foſſile calamy (for which end I have employed the Spaniſh) and *lead-glitter*, I have produced a formal beautiful *zink*, which, in any other method, would not ſucceed, at leaſt not with me. Nay, it is no uncommon thing to find calamy and *leadglitter* together in a vein, a ſample of which I can ſhew from Brilon in Weſtphalia: and it will be plain from conſidering but a little attentively, the loamy earth near Ulkos in Poland, wherein lead-ore lies irregularly huddled together, to which might be added other circumſtances; that there is ſomething ſeparable from the *zink*, which is not indeed pure lead, tho' approaching nearer to lead than to *zink*.

As I am perſwaded that this tinging ſubſtance is lodged in other earths and ſtones, beſides that called calamy, at the braſs-huts, ſo there are alſo other metals, beſides lead, out of which it may be educed; at leaſt I have found, upon working tin along with a cer-

a certain ore, without any the leaſt addition of calamy, if not a real corporal *zink*, yet its proximate infallible ſign, the genuine *philoſophical wool*. But without any ſuch experience, and from a ſlight knowledge of metallic bodies, the derivation from lead to tin is eaſy; but then in the fire this production is extremely diſſipable, *zink* burning away as quickly as it is produced, ſo that it is not procurable in our huts in its living ſtate; not from a defect of the proper matter for the purpoſe, as we may have ſuch in *furnace-fragments*; but then it is no longer to be catched *living* (from the following circumſtances, namely, the degree of the fire, the nature of the furnaces and *additions*, and the inexperience of the operator) but *dead*, and in its aſhes, from which, indeed, it is again recoverable *.

Formal *zink*, foſſil *calamy*, and *furnace-fragments*, or *cadmia fornacum*, appearing ſo different bodies, who could imagine theſe three ſhould be poſſeſſed of

* *Pott*, in his diſſertation on *zink*, makes zink to ariſe from the metalliſation of an alkaline earth, whence he deduces its ſolubility in acids, and that it conſiſts of a mercurial, vitreſcible, and a tender inflammable earth; the mercurial earth appearing from its flowing in the fire, its commixtion with mercury, and its mercurification; the inflammable earth, from its ready aſcenſion, when treated *per ſe* in the fire, as alſo from its fulmination with nitre; its vitreſcible earth, from its vitreſcency, which Henckel firſt accompliſhed in the vehement heat of a wind-furnace. But its ſpecific nature, and mixtion, he makes to conſiſt principally in the indeterminable, and ſcarce perfectly imitable combination of a copious inflammable principle, along with a certain peculiarly alcaline earth: and to this earth is owing both its difficulty of vitreſcency (ſuch as is alſo obſervable in tin) ſuperable only by a moſt vehement degree of fire, and the uſual bitterneſs of calcarious earths in ſolutions; and if, by means of the inflammable earth, it changes to a reguline body, is the cauſe alſo why copper changes to a yellow colour.

of one and the ſame virtue, or have one and the ſame *materia prima*, to tinge copper withal! or, who could think it poſſible to educe ſuch a matter from tin, without any addition of calamy, *zink*, and *cadmia fornacum?* Here I cannot omit tranſcribing Lohneiſs's * account, a conſiderable metallurgiſt of the *Hartz*, from which place alone *zink* comes to us: and though we might expect from him the beſt account of it, yet it happens to be conciſe enough, and ſomething fuller and more explicit, both on the origin of *zink*, and on the *Rammelſberg* ores, fit for the purpoſe, were to be wiſhed for. 'In the courſe of the ſmelting, (ſays 'he) a ſort of metal, there called *zink*, or *Contre-'fait*, collects below in the chinks of the fore-wall, 'or breaſt of the furnace, where not covered thick 'over, between the ſhiver, or ſlate, of which it is 'built. Upon knocking on the wall, this metal, 'which is white, like tin, yet harder, and more 'malleable, and tingling like a little bell, runs out 'into a trough placed underneath. The quantity 'procured at a time is in proportion to the care 'employed in collecting it. They ſometimes get 'to the quantity of two pounds, at other times, 'not quite three or four loths.'

Foſſile calamy, *lapis calaminaris*, called alſo *cadmia foſſilis*; under which laſt appellation we muſt not include the cadmia called *cobald*, yielding ſmalt; and which by way of diſtinction, both from that other cadmia, and other cobaldiſh, namely, arſenical ores, is called *cadmia pro cæruleo*. *Calamy* is a ſtone, or often a ſort of ſtoney earth only, ſometimes yellowiſh, ſometimes brown, and ſometimes a brown red; not only as it comes to us from other countries,

* Berg buch, p. 83.

countries, as Poland, Hungary, Spain, and the Indies, but as it is alſo found in ſeveral parts of Germany, as Bohemia, Franconia, and Weſtphalia. The heavier it is, it imparts the more a greater increaſe in weight, and a higher tint to the copper. It affects a loamy, claiey, fat bottom; and ſuch earths have even properties, manifeſting a no ſmall degree of affinity with *calamy*; it therefore lies not very deep, its mother-earth appearing commonly juſt under the turf, nay, conſtituting the uppermoſt layer, as at Tſcheren, near Commodau, in Bohemia, where it may be taken up at the *day*. This Bohemian ſort yields (1.) an iron-vitriol, as an actual iron-ſtone alſo *breaks* amongſt it; (2.) alum, a famous alum-work lying near the above place; and, I doubt not, but all *calamy-ſtone* in general do the like; but if you give it copper, a great part of the earth of the *calamy* incorporates with it, and aſſumes a metallic form and property; from hence it may be known, that braſs, into which about a third of its earth is introduced, will endure the being worked like any fine copper.

Calamy furnace-fragment, or *cadmia fornacum*, I have already conſidered, ſo far as it included *arſenical* particles; but muſt here again take it up, becauſe its nature and effects are entirely *zinky*.

Hither is chiefly referable what with us not only hangs in the upper parts of the furnace, but which alſo looks bright, particularly yellow and whitiſh, being tender, and not run together; alſo what ſettles externally over the fore-wall or breaſt of the furnace, between the chinks or openings of the ſtone, and the whole of that lower, mock-leady, ſlaggy, crude-ſtoney, caked matter, which, in the courſe of working the furnace, being ſtill ſoft, is beat

beat out with an iron, and called *ſweep*. From the lead-working, to which are taken, together with the *crude-ſtone*, and the *glitter-ores*, the burnt rich ſilver-ores, little or nothing is procured; as moſt ores, both the ſmalleſt or pooreſt ſort, have, by the operation of crude-working, and the rich ores, by that of *roaſting*, already loſt their aptitude for, and virtue of yielding *zink*: beſides, the *glittery* or lead-ores being, with us at Friberg, not in any conſiderable quantity, they cannot, without the evaporation of theſe laſt, exhibit thoſe zinky flowers they might otherwiſe contribute to ripen.

Were I to pick out, among the many ores and minerals, that come into the operation of *crude-working*, thoſe that contribute to form this zinky furnace-fragment, I would take the *glitter* and *pyrites* together; from the former I could derive the body, from the latter, the ſoul, and ſay, that the ſulphur and lead are become incorporated and animated by a peculiar appropriation and aptitude, and a number of unimaginable incidents, ſuch as eaſily happen in the large way of working, though not in the ſmall way of proof.

What the nature of this furnace-fragment, or *cadmia fornacum*, at the ſmelting-houſes of the Hartz, is, I know not; but referring the reader to Lohneiſs, ſhall only relate the ſucceſs of an experiment tried on Friberg *cadmia-fornacum* for braſs; for this purpoſe, I roaſted, after rubbing, the calamy under the muffle very ſmall, 'till it no longer ſmelt of *arſenic*: I took the ſort that, being longeſt expoſed to the air and weather, was become tender, or opened, as they ſpeak at the huts, this being eſteemed the beſt ſort, though for what reaſon I cannot imagine. After being well roaſted, I mixed

it

it with coal-duſt, in the ſame manner as is done at the braſs-works for foſſil calamy, and with this mixture I doſed the copper in the crucible, and by letting the whole flux, or run well together, procured a braſs like any other braſs, excepting that it is ſomewhat more brittle, though it may bear being drawn into wire as far as n° 15.

Among this furnace-calamy, forwards in the chinks of the furnace, about and over its breaſt, there is a ſpongy, woolly, white powder, but in ſmall quantity, uſually called at our houſes *hut-nothing*, alſo ſimply, *nothing*, or *nihilum*, which is the very ſame I mentioned above under the claſs of calamy flowers, as ſomewhat indeed *zinky*, yet likewiſe a little *arſenical*, and to be diſtinguiſhed from the proper *arſenic*-meal, called alſo *hut-nothing*, which commonly mounts higher. The genuine *arſenical hut-fume* is a noxious thing, not deſerving the name of that innocent drying matter, uſed for the eyes. *Nothing*, or *nihilum*, is an appellation in uſe alſo among druggiſts and apothecaries; and the celebrated M. Lincke, apothecary at Leipſic, informs me, our modern *nihilum* in the ſhops is only a tender, foſſil, white earth, or marl, *marga foſſilis*; and ſuch I myſelf have hitherto found it: ſo that it is highly neceſſary, on many accounts, druggiſts ſhould be ſubject to a viſitation and inſpection, equally with, if not rather than, apothecaries, as the latter are always ſupplied by the former with their drugs. Further, this ſhop-*nihilum* appears to me to be a kind of calx, or lime; M. Erhard, of Memmingen, informing me, that ſome apothecaries in Suabia burn ſpad to a lime, and ſell it in large quantities to the druggiſts of Nuremberg and Francfort, under the name *Nihilum*. *Nihilum*, or *nothing*, was, doubtleſs, formerly, among

druggiſts and phyſicians, only a calx, or flowers of burnt calamy-ſtone and zink, or the woolly, white, tender powder, ariſing and collected from the preparation of calamy or zink, for braſs or bronze-metal, or barely with this intention, and thus quite free both from *arſenic*, or other foreign admixture; as Pomet, an author deſerving more credit and commendation than moſt writers on natural hiſtory, has truly hinted. Hither again may be referred the abovementioned *nihilum* from ſmelting huts, after culling and thoroughly burning it, in order to purge it from the *arſenic*, though ſcarce equalling the other in tenderneſs and purity: yet neither are calamy, nor zink flowers, and a foſſil marl, one and the ſame in nature and effects: nor again, are marls one and the ſame, as I once found a ſort, ſold for a *nihilum*, to be *arſenical*.

Pomet writes as follows: 'Pompholyx, white *calamy*, white *nothing*, and *ore-flowers*, erroneouſly 'called *metal-aſh*, is what adheres, in the courſe of 'ſmelting for braſs, to the cover of the crucible, 'and the ſmelter's forceps; for, it is certain, that 'neither bell-metal, nor the *metal*, nor the *potin* '(a kind of braſs whereof pots are often made) but 'braſs alone, yield the genuine *nihilum*, though 'moſt writers have thought otherwiſe; there being 'naturally nothing beſides braſs, or yellow copper, 'that yields the white calamy, or *pompholyx*. But 'though *pompholyx* may be eaſily found, yet no 'one thing, either through the ignorance or negli-'gence of apothecaries, is more unknown; in re-'gard moſt of them are of the opinion, *pompholyx* 'and tutty, having one and the ſame virtue, may 'be ſubſtituted the one for the other. The moſt 'beautiful *pompholyx* comes from Holland; not 'that it is really a better ſort, but only on account

'of

'of its being collected in a cleaner manner. You 'muſt chuſe that ſort which is beautifully white and 'light, and will bear rubbing eaſily, and clean, *&c.* 'Bell-founders may, indeed, collect a little of it, but 'ſo very little, and beſides, not very pure, that it 'ſcarce deſerves notice. The bell-founder, by 'whom I ſaw *pompholyx* made, aſſured me, he ne-'ver ſold it but to particular perſons, who came 'and begged a drachm of him, to put into wine, as 'a drink in a fever; at the ſame time averring it 'to be an infallible remedy in that caſe; but I ne-'ver tried it, nor would I adviſe it to any body 'elſe, *&c.*'

Beſides this *nihilum*, there is another form, wherein zink lies concealed, namely, *tutia*, an Arabic, at leaſt an oriental term; the reaſon of which is as little underſtood, as why calamy-flowers come to be called *nil*. It might originally have denoted a kind of drying, aſtringent plant, as the plant *turbith*, the *ſpodium*, or aſhes of bones and plants, have been denominated from minerals, having, in uſe and virtue, ſomething in common with, or reſembling ſuch vegetable or animal parts. In like manner the term *tutia* was introduced into the mineral kingdom; and as we had this commodity originally from Alexandria, it was called *Alexandrina*, as it ſtill is at this day, from what part ſoever it comes. This appellation, 'tis true, is unknown in our ſmelting-huts, and conſequently does not cauſe that confuſion we experience from the term *but-nothing*. Now though we are directed by all the writers on the ſubject to the braſs-huts, and workers in braſs, yet I am at a loſs to conceive how this *tutia* can differ from the *calamy-nil*, as both of them ariſe in the making and ſmelting of braſs. *Nil* is calamy-flowers and a white powder; *tutia* appears like dark-

grey ſhells and rinds, and is alſo derived from calamy, but in appearance they greatly differ, which muſt be owing to different circumſtances and cauſes, of which I am entirely ignorant, and of which no explicit account is any where given. Here again, we give Pomet's deſcription of the *tutia* the preference to that of any other writer.

'The *tutia*, ſays he, denominated *Alexandrina*, alſo *ſpodium Græcorum*, is a metallic ſpecies, 'formed like ſcales or gutters (or rather, happens 'to be ſo formed) of different ſizes and thickneſſes, internally even and ſmooth, but externally 'like a ſhagreen, being beſet all round with grains 'of the ſize of pin-heads, whence it had the name '*tutia botrytes*. The *tutia* ſold in France comes 'from Germany' (alſo from Sweden, according to Lemery, in his dictionary of drugs) 'where it 'is prepared from braſs. We muſt not imagine, notwithſtanding its being affirmed by almoſt all ancient and modern writers, that *tutia* is derived 'from yellow copper, and ariſes at the ſame time 'with the *pompholyx*; this is falſe, the *tutia* adhering to the earthen cylinders, or rollers, ſuſpended in braſiers furnaces, for the purpoſe of 'catching the fume of the metal, whence the *tutia* 'has its ſhell or gutter-like form, and ſome of the 'pieces have earth ſtill ſticking to them. 'Tis externally of a beautiful mouſe colour, and internally of a white yellowiſh caſt, not eaſily broke 'to pieces', *&c.*

Here we have the form of our *tutia* plainly enough deſcribed, only the reader is not to ſtumble at our author's making a diſtinction between braſs and yellow copper, and allowing the *tutia* to be derived from the former, and not from the latter; whereas braſs and yellow

yellow copper are, with us, held to be one and the ſame thing, but among the French, the latter is made from formal zink, and ſuch yields no *tutia*; and as there is but little of it prepared, there muſt be but little demand for it: nor, at our author's ſaying, that *the tutia ariſes not at the ſame time with the pompholyx*; for, be this as it will, the *tutia* is derived from the very ſame principles with the *pompholyx*, namely, calamy, and tinges copper yellow. In ſhort, *tutia*, *nihilum*, *cadmia fornacum*, *foſſile calamy*, and formal zink itſelf, agree entirely in principles, though they differ in form and accidental appearance.

This digreſſion from *arſenic* to zink, cannot be thought diſpleaſing to the reader, ſeeing they are the effect of one operation, and, conſequently, have an affinity with each other; and, upon rightly taking the matter, the *pyrites*, either from its ſulphur or *arſenic*, aſſiſts to the production of zink: nay, it may be queried, whether, as Charras pretended, a zink may not be made from *arſenic*. Beſides, I wanted to clear up a ſet of names, ſometimes applied to one thing, ſometimes to another.

Arſenic, *orpiment*, *realgar*, and *ſandaraca*, ſtand for things, which if not entirely *arſenical*, generally partake conſiderably of it. *Orpiment* is a ſulphur-yellow, flakey, *arſenical* mineral, of which painters, with the aid of indigo, uſually compoſe a green. *Realgar* is an unknown term, with ſome denoting the ſame thing as *arſenicum cryſtallinum flavum*; with others, *arſenicum rubrum*, or the common ſandarach; yet it always means ſomething in which the *arſenic* is the principal part, and the ſulphur, which, in both the red and yellow, makes

the diſtinction, is, in the former, ſomewhat more, and in the latter, ſomewhat leſs in quantity. *Sandaraca*, properly denoting a gum, or roſin, is here alſo applied to a mineral, which is, or appears to be gummy, or fatty. Now, 'tis true, genuine ſulphur is of ſuch a nature and form, but by it this laſt is not meant, but ſomething arſenical, only combined with ſulphur; and, in ſhort, ſuch a body as, be it white, yellow, or red *arſenic*, may, both by a lixivial and acid ſalt, (which is ſomething very extraordinary) in particular by ſpirit of nitre, be changed into a formal gum.

We are, in the next place, to enquire into the origin of *arſenic*, or whence it is derived. And (1.) 'tis found in the earth ſo pure and ſnow-white, as ſcarce to be rendered more ſo by art; but this is a very rare caſe. So far as I have been able to judge from circumſtances, it may lie unobſerved by coarſe veins, conſiſting of *pyrites*, *miſſpickel*, *mock-lead*, and *glitter*; yet the *arſenic-pyrites* commonly, and in large quantities, *breaks* among them, and chiefly contains the *arſenic*. At Friberg we know nothing of this *arſenic*, the ſamples I have either ſeen, or actually had in my poſſeſſion, being only from the mines of Joachimſthal, in Bohemia, where the veins conſiſt, together with *red-goldiſh* ore, both of the ſmalt-cobald, and that other black *arſenic*-ore, of which more by and by, uſually called *cobald*, but really a kind of pure fly-ſtone, or ſooty *arſenic*.

Whether this white, foſſile *arſenic* be an original production, whoſe particles, before thus exhibited, were not *arſenic*, but firſt became ſuch in the exhibition; or rather, whether its origination conſiſts only in a ſeparation from another body, wherein indeed

indeed it cannot have lain as a ſnow-white powder, yet as a formal *arſenic* in an ore form; as neither ſulphur is made from *pyrites*, nor quickſilver from cinnabar, but both of them ſeparated from theſe bodies, is a queſtion that has ſome difficulty? The firſt is not impoſſible, ſimple bodies firſt uſually ſeparating from mixts or compounds; yet the ſecond is the more probable, as the black *arſenic*-ore, conſequently, what is prepared to hand, is not combined with any coarſe, fixed earth, to unfit it for ſuch a degree of fining and whiteneſs; not to mention the genuine ſmalt-cobald, which often, in certain circumſtances, is ſeen diſſolveable both in the upper and lower *weatherings*, a circumſtance never obſerved in a *miſſpickel* or *arſenic pyrites*, however long expoſed, as I myſelf have remarked, in all manner of air.

What makes this ſpontaneous purification of the *arſenic* a difficult matter to be credited, is the prejudice entertained, that the action of the fire is abſolutely neceſſary for that purpoſe; though nothing is more evident than the ſpontaneous reſolution and vitrioliſation of the *pyrites:* and at Wenſeen, in the territory of Lauenſtein, in the Electorate of Hanover, a beautiful, tranſparent, yellow ſulphur *breaks*, beſides in ſeveral parts in Hungary, without the action of any obſervable fire; and the mercurification of metals, or rather their ores, is no other way to be fundamentally laid, than by gentle macerations, with appropriated ſalts and ſaline waters, and by the action of the inſipid, powerful body of the air.

(2.) *Arſenic* is alſo often found in the earth perfectly native, without any other admixture, yet in a different form; I mean a ſemi-metallic fly-ſtone

ſorm. This ore generally looks externally of a dark-grey, and ſometimes quite black; yet, upon breaking, it appears of a bright, metallic, leady colour; but upon lying expoſed for a while in the air, is again overcaſt with the ſame blackneſs as before. Externally it ſeems like *teſtaceous cobald*, as if made up of ſhells laid one over the other; yet, internally, theſe run all into one another, without further diſtinction of layers. Some alſo call it *cobald* and *teſtaceous cobald*, eſpecially miners, who call every thing cobald, that is either poiſonous, or with which they are unacquainted; though the more cautious and diſtinct appellation would be, *black poiſon-ore*, foſſile *fly-ſtone*, or even *foſſile black arſenic:* for, in its genuine *mixtion*, without any other mineral adhering to, or interſperſed with it, it is not only entirely fugitive, not leaving the leaſt fixed earth behind, but in the fire it exhibits altogether the ſame appearance as the factitious fly-ſtone from *miſſpickel*.

It was formerly dug for at a certain Miſnian *arſenic*-work near Schwartzenberg, and the Joachimſthal, in Bohemia, is remarkable for it; and it is ſaid to be no ſtranger at Johan-Georgen-Stadt and Ehrenfriderſdorff in Miſnia, where the beautiful, tranſparent, *red-goldiſh* ore *breaks*. The circumſtance, namely, that ſuch *red-goldiſh* ore affects, or is affected by this poiſon-ore, muſt yield no deſpicable hints to diligent enquirers into nature; though I would be far from affirming the *red-goldiſh* ore to be produced from it: but here let the proper caution be made uſe of which a careful one ſhould ever keep in his eye, when, for avoiding fallacious concluſions, he would judge of the origination of two ſorts of ores, lying near, or entangled in each other.

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As one or other circumſtance might eaſily miſlead us to a falſe concluſion; for inſtance, that this *red-goldiſh* ore is highly, nay, I had almoſt ſaid, allowing for its ſilver contents, entirely *arſenical*, and not ſulphureous: further, that another ſilver-ore, as the *glaſſy*, which has only ſulphur, and no *arſenic* for its mineraliſing cauſe, is, however, not to be found there; (unleſs it ſhould happen to be conveyed thither, as things the moſt foreign may, from other veins) whereas otherwiſe it is not uncommon for *red-goldiſh* and *glaſſy* ores, readily to lie near, and to be entangled in each other: moreover, that otherwiſe no ſulphur-ore is found there; omitting other circumſtances which might be mentioned; as, that the *red-goldiſh* lodge in this poiſon-ore as ſo many kernells in their ſhells. This, however, I muſt here ſay for *arſenic* (not out of any alchemical views, but only in regard to its univerſal treatment in ore-ſmeltings, and the like, and from ſome experience I have had of it) that it wants not a great deal to become a ſilver.

(3.) *Arſenic* may be ſuppoſed both to lodge in, and to be actually educed from foſſile ſandarach; as it is certain, ſandarach conſiſts of that and ſome ſulphur. This mineral is alſo found in the foſſile orpiment, partly kidney-wiſe, partly as ſo many fibres, alſo ſeparately in fiſſures in the barren rock, as I have had it out of the ſulphur-grooves, both from Cremnitz in Hungary, and from Turkey, likewiſe from Frantz-Coronzay, near Tobaga, by Neuſohl, in Hungary; affording the ſame hints to the enquirer, with reſpect to its origination, as were above given for the foſſile white *arſenic*. Now both ſorts, 'tis true, eſpecially the ſecond, are things very rare and uncommon in mineral collections; and I dare affirm, a perſon intelligent in the nature

nature and encheireſis of *arſenic*, may in this ſame native ſandarach, hit upon ſomething to his purpoſe. The means of ſeparating the *arſenic* from its adhering ſulphur, and thus exhibiting it pure, is to add ſomething, to which the ſulphur more readily faſtens; whereby it will let go the *arſenic*. This is the foundation of all ſeparations, and what gives a hint for finding out other means to the ſame end, that would otherwiſe remain unknown.

(4.) *Arſenic* is found almoſt in all, or at leaſt moſt ores; ſometimes only incidentally, ſometimes eſſentially: in ſuch manner, that beſides its little or no other fugitive ſubſtance, capable of reducing metals to their ore-ſtate, which ſulphur and arſenic alone effect, can be ſhewn from ores; incidentally it lodges in almoſt all *ſulphur-pyrites*, as may certainly be concluded from the deſulphuration of the pureſt ſort; from the never-failing grey colour of crude ſulphur; and from the ſandarach, tho' ſmall in quantity, procured from fining ſuch crude ſulphur; though ſome ſorts of *pyrites*, particularly the round, yet that not always, ſtand excepted. The *copper-pyrites* and copper-ores contain ſomewhat more of it, and the richer in it, the richer they prove in copper, and the poorer, the leſs copper they afford: and by my experiments, none is procurable from them when they are purely martial; and in a ſort of copper-ores, looking almoſt like a white *pyrites*, in the volatile part the *arſenic* is the principal; whence alſo the white colour ariſes; whereas otherwiſe in *copper-pyrites* and ores, the ſulphur generally predominates.

In the *lead-glitter*, the lead has left but very little room for it, being almoſt all of it, enveloped in pure ſulphur. On the contrary, *arſenic* lodges eſ-

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ſentially in the *red-goldiſh* ore, as appears by the ſmell in roaſting, by the poiſon-meal procured in ſublimation, alſo from its relation to iron: ſeeing it does not part from, but rather runs together with it into a cake, without letting fall the ſilver, like as a *ſulphurated* ſilver does; for inſtance, the glaſſy ore, after the manner of an antimony. And here it is worth remarking, that the *red-goldiſh* ore uſually manifeſts itſelf in the fire no other than as a ſpad, by its ſtarting and ſpringing.

Arſenic lodges in *white-goldiſh* ore, *fallow* ore, *fallow-copper* and white ores: the firſt, on the ſcore of its ſilver-yield, belongs to the claſs of ſilver ores; the others, on account of their copper-yield, to that of copper-ores.

Arſenic in the *cobalds*, from which the ſmalt is prepared, and in the *kupffer-nickels*, which are allied to cobalds, is all in all, as not to exhibit the leaſt ſulphur, as ſuch. The finer tin-ores, called *zinn-graupen* (not the coarſer, called *zwitter*, ſuch a mixed maſs being never without *arſenic-pyrites*, *wolfram*, &c. and yielding with us the greateſt quantity of *arſenic-meal* for the *arſenic-huts*) beſide their metal, conſiſt of nothing elſe.

There are alſo *arſenical* lutes, clays, or marl-earths; as here in the *Herrn grund* at the *Beſchert-gluck*. In ſtone I have not hitherto diſcovered any, but, I cannot ſay, I ever examined them with that view, tho' I have often for ſulphur. In water we may rather expect to find ſulphur than *arſenic*; yet there are inſtances of *arſenic*'s inſinuating into mineral waters; and it may, by art, be incorporated with water, in conjunction with ſulphur and vitriol,

triol, without which it cannot; as I have ſhewn from the *Friberg-ſchlacken-bade* *.

(5.) *Arſenic* lodges in *pyrites*, and eſſentially in the white ſort. This *pyrites*, and the ſmalt-cobald, are here at *Friberg* the principal ſorts; the former is a whitiſh ſort, conſiſting of iron, a crude earth and *arſenic*; not ſo readily found as the other ſorts, and never under the under-turf earth, nor readily in ſquats, but commonly in veins. At *Friberg* in particular, it *breaks* near coarſe veins, as mock-lead, ſulphur, copper-*pyrites* and *glitter*; particulary, it every where accompanies mock-lead: in the *Obergeburg* it readily lies near *Zwitter*: beſides iron, it contains but a very inconſiderable ſhare of ſilver; it is picked out from among our ores, as being not only unſerviceable in our ſmeltings, but alſo rapacious, or detrimental to the procuring the full yield of metal; its *arſenic*, if not well diſcharged at firſt, manifeſting its ill effects not only in the lead and copper works, but alſo in the buſineſs of cupellation, beſides proving prejudicial to the litharge. It is uſually employed for making *arſenic*, tho' only incidentally with us, on the ſcore of the charges. The *arſenic* riſes out of it, and cobald, like a white-grey fume, ſettling like a white-grey powder in the receptacles prepared for it, as in ſo many aludels. The proportion of *arſenic* in ſuch *pyrites* is generally a third, and rather over than under: and thus, it exceeds the proportion of ſulphur in the *ſulphur-pyrites*, which at moſt amounts but to a fourth of the other conſtituent parts: and theſe proportions are the more to be remarked, as they do not offer only in a few inſtances, but are obſerved to hold conſtantly.

* Breſlaw Collection, P. 9.

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We ſhall now conſider the properties of *arſenic*, or rather its ore; (1.) In the earth. (2.) Air. (3.) Fire.

(1.) Its bed in the earth we have already conſidered; only this circumſtance is to be added, in which it differs from the *ſulphur-pyrites*; *viz.* that it always *breaks* near other ores; and only in fiſſures and veins, never in *neſts*, as the *ſulphur-pyrites*. The *white-pyrites* does not diſſolve, crumble, vitrioliſe, or in the language of miners, become *weathered*, as the yellowiſh and yellow do, eſpecially the firſt; for (1.) it contains no acid ſalt, as ſulphur does, capable of exerting itſelf, and faſtening on the iron-earth to the deſtruction of the whole texture. (2.) *Arſenic* and iron, of which the white *pyrites* conſiſts, are too cloſely entangled, much more ſo than ſulphur and iron. Whence might be ſooner ſurmiſed the *weathering* or diſſolution of the foſſil black *arſenic*, or *fly-ſtone*, as being combined neither with iron nor any thing elſe. *Laſtly*, the *arſenic* in the above-mentioned clays, alſo the pure, white *groove-arſenic* of *Joachimſthal*; being the *former* (from the mentioned clays being at the ſame time vitriolic) a *ſulphur-pyrites*; the vitriol, ariſing from the deſtruction of the ore, carries along with it, by means of the water, that ſmall *arſenical* portion mixed in therewith; the *latter* has for its ground the adjoining black-grey *poiſon-ore*, not our arſenic *pyrites*, as not being found near it.

(2.) In the air, the *white-pyrites* maintains itſelf no leſs conſtant and unchangeable in its *mixtion*, in what manner, for what time, or in what place ſoever it be expoſed. Nay, it needs muſt, as it is evident, *arſenic* is the grand, if not the only cauſe, why the

ſulphur-

ſulphur-pyrites, that are but a little *arſenical*, require more time and labour, nay even ſhow almoſt an impoſſibility of diſſolution. It is ſomewhat peculiar to the ſmalt-cobalds, that they ſtrike out a kind of peach-blooms; and alſo under certain encheirſes, yield a peculiar vitriol; nay the pure ſort do the ſame, even ſuch as manifeſt neither the leaſt ſulphur, nor *ſulphur-pyrites*; though it may be queried, whether the biſmuth-ore, which often quite unobſerved, lies interſperſed amongſt it, be, if not the principal and ſole cauſe, as ſeems probable, at leaſt a concurring cauſe: or, whether the cobald itſelf, which may here be alledged inſtead of the genuine *arſenic-pyrites*, be itſelf capable of ſuch a change.

(3.) The relation of the *white-pyrites* to the fire may be conſidered, partly in regard to the fire itſelf, partly to the other bodies. As to the firſt, moſt of the remarks, that give any light to the knowledge of this ore, have been mentioned above: but ſome things ſtill want to be cleared up; which may be beſt done by comparing it with the *ſulphur-pyrites*, and reducing what we have to ſay on this head to a few ſhort propoſitions.

(1.) The *white-pyrites* parts with its *arſenic*, of itſelf, without any *additions*, in which it agrees with the *ſulphur-pyrites*, tho' not with the ſame promptneſs, but rather reluctantly, and not without a conſiderable degree of fire. The reaſon is, becauſe *arſenic* ſticks cloſer to its earth than ſulphur does to *its* earth, which in the former is ſomewhat more crude, in both, irony; inſomuch, that in ſomewhat too briſk a fire, it is apt to cake or run, rather than to ſeparate, whereas the ſame does not happen, ſcarce even by means of art, with reſpect to the *ſulphur-pyrites*. This the *arſenic* very plainly ſhews, when combined

bined with ſulphur; and in copper-ore, with a copper-iron earth: and this gives a hint to roaſt with the greateſt caution, not with a ſtrong, briſk fire, both the copper-ores for copper-proofs, as theſe never want arſenic, and the cobaldiſh ſilver-ores, for ſilver: alſo to burn well and with the greateſt attention the copper-ſtone; as in the one a caking, or an impure ſilver-grain, may be expected; in the other, a great deal of *arſenical* impurity in the black-copper, with a large ſhare of copper *ſpeiſe* or *leg*. Why *arſenic* adheres more obſtinately than ſulphur, is, doubtleſs, owing to its being a metal, at leaſt a ſemi-metal; whereby, in its entire nature, texture, and weight, it muſt approach nearer to an actual metal-earth, either iron or copper, than the tender, light, ſaline, and inflammable body of ſulphur. Nay, all *arſenical* ores let go their fugitive, poiſonous portion; for inſtance, cobald, whether or no it yields ſmalt, alſo *kupffer-nickel*, *red-goldiſh* ore and *zwitter*. Yet here we muſt not omit obſerving, as ſomething very remarkable, that the *ſulphur-pyrites*, when not at all, or but little *arſenical*, yields its ſulphur very readily, and without leaving any reſidue; though the ſulphur, which is along with the lead in the *glitter* or galena, takes a longer time for ſeparation; ſticks cloſer ſtill to the regulus, as is but too well known from its incineration for making the glaſs, and rather carries off quickſilver along with itſelf than lets it go.

It may be aſked, whether it be not poſſible ſo to unite a metal with arſenic, as to ſublime it therewith, in the ſame manner as we do ſulphur and quickſilver.

And here (1.) the queſtion is not concerning a ſmall quantity of metal, as all *arſenics* may thus affect all ſorts of metals; for inſtance, the lead and the

the ſilver in the *lead-working*, the copper in the *black-copper-working*.

(2.) Sulphur and *arſenic* have no other affinity than that they are the two grand cauſes of mineraliſation, or of reducing metals to their ore-ſtate, and that only in regard to iron and copper: but if any thing muſt be put on a footing with *arſenic*, it muſt needs be quickſilver rather than ſulphur. *Arſenic* is a ſemi-metal, quickſilver not much other. So that the queſtion is reduced to this point, whether the *arſenic* will not alſo, like quickſilver, bear the being combined and carried over along with the ſulphur: and for this the ſandarach affords a plain anſwer, and an ocular demonſtration; as in this caſe, the carrying over of the *arſenic* by the ſulphur, happens as in the manner of quickſiver, that the third body, namely the ſandarach, educed from theſe two, may be conſidered as a *philoſophical cinnabar*.

Moreover, *Arſenic* holds firmer ſtill in its *pyrites*, when either by accident, or with deſign, it happens to cake or run together with its accompanying iron-earth; which ſhews it would ſtand the fire, and that it wants ſomething in iron for that purpoſe. The relation of iron to other metals has been ſhewn above, chap. iv. by the magnet.

(3.) 'Tis no wonder, that *arſenic*, in its ſeparated ſtate, can ſo very difficultly be again introduced into ſmelted iron; even as difficultly as it is to exhibit a *ſulphur-pyrites* by art; ſeeing it depends on a due appropriation of the iron, and the properly exhibiting its earth-form. On which encheireſes and circumſtances, many, and thoſe the moſt important combinations, eſpecially in the imi-

tations

tations of nature, entirely depend. With *ſulphur-pyrites* it in ſome meaſure ſucceeds; as the ſlag, which ſometimes ſettles on the lead, depoſited out of lead-ore by means of iron, and which certainly conſiſts of iron and ſulphur, is to be regarded as a kind of *pyrites*.

(4.) The *arſenic* in the *white-pyrites* is not ſufficiently ſaturated with iron-earth, but can ſtill bear with facility almoſt as much again, as it had already received; as may be ſhewn by its *regulation*, which is performed with iron. We have pure, clean ſulphur, alſo pure clean *arſenit* in the bowels of the earth; and thus they may not only conſiſt, but be alſo produced without iron.

(5.) The *white-pyrites* contains alſo a little ſilver; in this entirely agreeing with the *ſulphur pyrites*. But when *arſenic* is combined with an earth, yielding ſmalt, and then called *cobalt*, it becomes remarkably more ſilvery, yet in variable degrees: this we alſo obſerve of *ſulphur-pyrites*, when its iron-earth is coppery. And the comparing together of the *white* and *yellow pyrites* in general, with reſpect to their earths; at one time yielding ſmalt, at another copper, and the exaltation of their ſilver-yield hence viſibly depending, would be worth our peculiar attention. And he who would verify his ſuſpicions about noble *miſſ-pickels*, ſhould accurately examine the ſample he is about to employ for proof, in order not to be deceived by other unobſerved, interſperſed veins therein.

(6.) The *pyrites* gold is not very common. As I would not be impoſed upon by the *white*, as little would I by the *yellow* colour of the *ſulphur-pyrites*. I am well aware of the difference between white and

yellow metals, a difference no way groundleſs; but there are middle metals, and theſe ſtand ranged with the intermediate quickſilver, and arſenic certainly ſhould not have been excluded.

(7) The fugitive portion of the white *pyrites* is almoſt as well affected and inclined to iron as to biſmuth, tin, and zink; whereas regulus of antimony, and lead, are ill affected and unfriendly thereto; ſeeing the latter can at no rate bear it nor run together with it, even when *dead*, or reduced to a glaſs. The former, indeed, unites with it at length, but deſtroys it: for the magnet, as above mentioned, touches not the iron, that is ſmelted with regulus; whereas it has the leaſt averſion poſſible to *arſenic*, tin, zink, and biſmuth, even ſhould the iron happen to be ſtrongly doſed with them.

(8.) White *pyrites* holds no ſulphur, nor any ſandarach.

(9.) It ſmells in the fire like garlick; its ſmell is biting-ſharp or pungent.

(10.) It diffuſes its ſmell in the air to a greater diſtance than ſulphur does.

(11.) In the ſtrongeſt degree of fire it leaves a black glaſs behind, as we experience of any other iron mineral.

(12.) *Arſenic* makes copper white, but at the ſame time brittle.

(13.) It leaves iron its colour, and makes it eager alſo.

(14.) The

(14.) The glaſs, to which it runs along with lead, is ſomething extraordinary: not to mention other remarks at preſent.

Once more; *arſenic*, *zink*, and phoſphorus, ſtand greatly allied to, and probably are derived from each other. Zink and phoſphorus are bodies ſuſceptible both of fire and flame; the former, only by an external accenſion; the latter, by an internal ſelf-motion, by means of the air. Zink ſmells fetid, like phoſphorus, and phoſphorus ſmells like hut-ſume. Phoſphorus unites with quickſilver. *Arſenic* and quickſilver are nearly allied. In *cadmia-fornacum* there is an actual, tho' not a formal zink. *Arſenic* certainly lodges in, and zink is only derived from ore: yet they are produced one after the other; firſt, the *arſenic*, then the zink; they alſo adhere to each other. Phoſphorus too may be prepared from *arſenic*, or an *arſenical* body.

Reader, weigh well what I have already mentioned on this head; and here, for thy further information, take an extraordinary experiment of the celebrated Dr. *Meuder*'s *Dreſden*, lately diſcovered by him, and imparted to me: Take orpiment and iron-filings, equal parts, and ſubliming the mixt maſs in a body or cucurbit, among the ſublimate, thus procured, rub in on a porphyry, ten or twelve parts of lunar cryſtals; then ſhooting out the whole on paper, it will inſtantly take fire.

CHAP. XI.

Of the Silver in the Pyrites.

AS to the *ſilver* in the *pyrites*, it is an undoubted truth, allowed by every careful aſſayer, and which I myſelf have experienced, that *pyrites*, as ſuch, never holds above half a drachm of ſilver in the centner. For, tho' ſometimes the proofs ſhould riſe to 1, 2, 3, 4, 5, and 6 drachms, as I have often obſerved ſuch various *yields*, we are at the ſame time to know (1.) That ſuch ſort of *pyrites* is commonly coppery; and that the copper therein is, if not the cauſe, yet the ſign of the admixture of other ore. (2.) That ſuch yieldy *pyrites-mixt-work*, or *pyrites-meal*, has often other veins unobſervedly interſperſed amongſt it, which may greatly raiſe and heighten the *yield*; and to this ſort may be ſometimes referred the cubical, marcaſitical *pyrites*, ſuch as thoſe of Pretzſchendorff, which appear pure and unmixt, tho' internally they make an appearance of being *glittery* and *mock-leady*. (3.) That hence the proofs vary much, nay ſometimes ſo far as to fall ſhort of half a drachm.

The ſame thing holds of the *white pyrites*, namely, the *miſpickel*, or *poiſon-pyrites*, an half, or a quarter of an ounce may often be procured from them; but a drachm, half a drachm, and next to nothing at all, are generally what the *proof-ſchedule* ſhows. Yet here, for particular reaſons, I muſt allow ſome ſilver to the *white* rather than to the *yellowiſh*, or ſulphur *pyrites:* and I have been informed from Sweden, that they have there a *miſpickel* of

of four ounces in *ſilver-yield*; though it may be queried, whether ſuch be a pure *miſſpickel*, and not rather a ſmalt-cobald, theſe being often not eaſily diſtinguiſhable, and generally *ſilvery*. But here again I find, even a *miſſpickel*, that *breaks* in amongſt the nobleſt veins, tho' rarely, to be no more *ſilvery* than another from coarſe veins.

But when the *pyrites* is coppery, as from the copper-yield we may ſuſpect the coction of ſome other ore and metal, we may then rather hope for *ſilver*, tho' not conſtantly, not indeed as an eſſential, but as an incidental part of the *pyrites*, in the ſame manner as copper itſelf is ſo. Nay, this incidentality of the *ſilver* in *copper-pyrites* is ſtill ſo uncertain, that there is no meaſuring or proportioning the yield of the *ſilver*, as might be imagined, by that of the copper. But there are *copper-pyrites*, very rich in copper, which nevertheleſs do not yield the more *ſilver*, nay ſometimes yield leſs than thoſe that are poorer in copper. And here we muſt be upon our guard againſt being impoſed upon by names given to *pyrites*, either from the colour, the *ſilver-vein*, where they *break*, or their uſe in ſmelting for *ſilver*.

Thus, from Norway, I have had, under the title of a *ſilver-pyrites*, a barren ſtone or rock, conſiſting of ſmall, tender layers of *quartz* and *glimmer* interchangeably, with foils or ſpangles of *ſilver* upon it, where it had been broke off. Now, not to mention, that we are not careful enough to diſtinguiſh *pyrites* from flint or *quartz*, which this ſtone really was, I ſhall here only obſerve, how farfetched ſuch denominations often are, which point not at the eſſence, but accidents of things; as ſuch pretended *ſilver-pyrites* hold no *ſilver* of themſelves,

but happen to be furniſhed with only ſuch as is adventitious and foreign. The ſame judgment we ought to paſs on the Latin appellations, *pyrites argenteus*, or *argentarius*, as taken either from the colour, and denoting the ſame as *pyrites argentei coloris*, and thus only a *white pyrites*, of which in the preceding chapter: or, from its holding ſilver only without any other metal, as * *Rulandus* affirms; whence it ſhould rather have ſome other name than that of *pyrites*. After all, ſo little *ſilver* is to be expected from *pyrites*, that were not the *ſulphur-pyrites* ſerviceable for making the *crude-ſtone*, or for ſulphur and vitriol; and the *copper-pyrites* ſerviceable for copper, it would not be worth while to dig for and ſmelt them.

* Lex. page 390.

CHAP.

CHAP. XII.

Of the GOLD in the PYRITES.

IF ſilver hath no great ſhare in the *pyrites*, gold has ſtill much leſs: I, for my part, find little or none therein, though nothing be more common in the mouths of men than the names, *gold-pyrites*, *gold-marcaſite*. It is, I own, no ſmall pain to me, to be obliged to contradict what ſo many ingenious and learned perſons before me have aſſerted to this purpoſe; however, I cannot help expoſing ſuch pretences, ſeeing even what actual *gold*, after the greateſt care and attention, we may happen to procure from *pyrites*, proves very inconſiderable, and next to nothing; and then it may be queried, whether it was actually in it, or produced by means of the proceſs and *additions*. 'Tis abſurd to pretend, in ſupport of the common opinion, the volatility of this *gold*, as it may be aſked, what the appearance, and what the ſigns are, by which it may be diſtinguiſhed? We have, 'tis true, volatile metals, in particular, the common and philoſophical leads; nay, all metals may be volatiliſed.

But it will be alledged, there is no catching this volatile *gold*, *in an open fire*; but may not ſubliming veſſels be employed, by means of which, a little of what the violence of the fire forces off may be recovered in order to trial? But, to ſave my reader a good deal

deal of trouble, I can aſſure him, that after having examined all the ſorts of hut-fumes, from the ſeveral operations of *crude-working*, working for lead and copper, and thoſe from the fining-hearths, with a view to this volatile *gold*; I found, indeed, a ſmall ſhare of ignoble metals, in particular, lead and copper, alſo a little ſilver in the lead, but never the leaſt ſign either of a volatile or fixed *gold*; as thoſe employed at the roaſting-hearths and ſmelting-furnaces, for collecting the diſſipated ſilver, and who having aſſayed the ſilver procured from the fume, for *gold*, will readily own. Tho' had this ſurmiſe any foundation, the *gold* could not fail ſhewing itſelf in ſuch hut-fumes, where *pyrites* of all kinds, and in all quantities, are worked, in a degree of fire, where all metals muſt become fugitive. That in Hungary and Tranſilvania ſome *gold* ſhould be procured from the fume-works, we are not to wonder, as their ores contain a fixed *gold*, which, like the ſilver with us, may be carried off in the arſenical fume in very minute particles; but, by the method of depart, or by the aſſay-furnace, no violence of fire can be charged with volatiliſing the *gold*; and yet in neither of theſe ways do we diſcover any in the *pyrites*.

Should it be further alledged, that it is only an immature, or embrionated *gold*, this is no more than a mere ſubterfuge; 'tis as eaſily ſaid, that cobald, tin, and the like, are an immature ſilver, as is, indeed, often ſaid, but never proved; tho' it muſt be allowed, tin, and the like, greatly reſemble ſilver. *Pyrites* alſo boaſts of its beautiful gold yellow, which has ſerved to deceive many, without their being able to procure any one ſort of *gold* from it.

I would

I would not here be underſtood as depreciating the following propoſitions, *viz.* (1.) That a perfect, or, if you rather chooſe it, a ripe metal, may be made from an imperfect metal. (2.) That ſome *pyritæ* are not entirely without ſome ſmall ſhare of *gold*. The firſt the experience of every one may affirm, in the leaſt converſant in the buſineſs of minerals and metals, with any care and attention; though the thing cannot be reduced to any certain theory or rule, to be depended on at all times. But in all theſe proofs, where, for inſtance, copper and iron particles are tranſmuted or converted to *gold*, as alſo ſome particles of lead, tin, regulus, *&c.* to ſilver, it by no means follows, that iron and copper are an immature *gold*; or lead, tin, and regulus, an immature ſilver.

For, though I might call ſuch a converſion a maturation, and though there were inſtances thereof, yet it ſtill remains a queſtion, whether other, nay, all eductions of the nobler metals, where a formal tincture is not employed (and ſuch proceſſes may, in ſome meaſure, be called *particular*) are only *productions*, ariſing, as a third thing, from the running and mixing together of two or three ſorts of particles, and not, in effect and propriety, *eductions*, not always to be denominated maturations, or tranſmutations.

It is one thing to tranſmute a ſalt, for inſtance, to volatiliſe common ſalt *per ſe*, which is certainly practicable; another, to educe a ſalt by the addition of a ſecond and third matter, as an *oleum vitrioli dulce*, by means of quicklime, or a lixivious ſalt, as is a well known caſe.

Metals,

Metals, undoubtedly, are near allied to each other; though why ſuppoſed ſo only in the aſcending, and not the collateral line? and philoſophers borrowing the term *maturation* from the vegetable kingdom, it is only in the way of compariſon, and ſerves merely as a demonſtration, but does not amount to an illuſtration: either it is out of a certain deference to the *great work*, they forbear the uſe of the term *tranſmutation*; or, to avoid falling by the ears with the Ariſtotelians, who, from their doctrine of *genus* and *ſpecies*, diſclaim all tranſmutation of metals.

Before I enter upon aſſigning the quantity of *gold* procurable from the *pyrites*, I muſt premiſe my method of taking and working the proofs. For the firſt, with the greateſt care and attention poſſible, I pick out the pure ſteely or cloſe ſort; then, as the *gold* in the *pyrites*, if any, is only to be had by procuring its ſilver, in the *grain* of which the *gold* lodges, I have accordingly made the proofs for ſilver; and as, generally, the *ſilver-grain* proves to be very ſmall (and neither the ſmalleſt nor the largeſt is to be aſſumed) namely, in the *ſulphur-iron-pyrites* amounting to half a drachm, and in *copper-pyrites*, or copper-ore, to two drachms; with ſo very ſmall a *grain* there is no making a certain proof for *gold* by the *depart*; I have therefore worked between ſix and eight centners at once, on as many different aſſay-pots and copels, and, at laſt, run the ſilver together into one *grain*, which afterwards committing to the *depart-water*, I, after edulcoration and ignition, weigh the black calx. I hold this to be the beſt method, as it ſuperſedes, if nothing happen to be procured by it, the ſeveral operations of cementation, maceration, ignition, and extinction, if you will ſuppoſe there is any *gold*; for, ſome

ſome of theſe, particularly cementation, may have ſome effect as to the encreaſe of the gold.

To educe the *gold* out of the *pyrites* by *aqua regis*, ſeems to be an uncertain method, as the *gold* is generally entangled, not only in much foreign admixture, but in ſuch metals, as copper and iron, on which *aqua regis* equally works as on *gold*; yet this I have alſo done, and, after *incoction*, copelled the precipitated maſs, but without any effect: nay, if by the former method I procured any thing, by the latter, on the contrary, I have rarely ſucceeded at all, or in a far leſs quantity.

In pure *ſulphur-iron-pyrites* there is not the leaſt *gold*, a thing well to be obſerved, even ſhould it happen to be the *minera martis ſolaris Haſſiaca* itſelf, the ſulphur of which, for its high purity, is greatly to be valued (but its vitriol muſt yield to a factitious, pure iron-vitriol, but much more to a vitriol from calamy, alſo to the green, foſſile, Hungarian vitriol) but its *gold* is only imaginary: much the ſame holds of thoſe *iron-pyrites* which are but very little coppery, as alſo of moſt *pyrites* in nature. Among theſe there is now and then a proof, where the *mark* of ſilver holds about one quarter, or one half, or one *heller* * of *gold*; but when the centner or quintal of ore gives forth one, one half, nay, only one quarter of a drachm of ſilver, and you come to calculate the number of centners of ſuch ore, neceſſary for the eduction of a mark of ſilver, the *gold* to a centner muſt be very inconſiderable, nay, not to be calculated, much leſs be viſible, or be manifeſted by the moſt tender, ſenſible ſcales; can it then be thought worth while to mention *gold* in this caſe?

But

* Seven hellers make a penny weight, thirty-two hellers a loth, or half ounce.

But it will be alledged, the *copper pyrites*, and *rites-copper-ores*, as copper is nearer allied to *gold* than iron, yield ſome *gold*; yet with theſe, after all my labour and trouble, I ſucceeded no better. It may indeed happen, that ſome Hungarian ſorts, which have ſerved to ſet the world a-gog after *copper-pyrites*, ſhall give ſome evidence of their containing *gold*; but of theſe hereafter. One would not readily ſuppoſe *gold* to be in the white or arſenic *pyrites*, ſeeing it does not appear yellow, but of a ſilver white, which is the reaſon the beautiful yellow *pyrites* have been pitched upon, though that yellow caſt be only owing to their ſulphur, and afterwards heightened by the copper, nay, often ſuperficial only; and as little from the colour muſt we imagine ſilver in the white *pyrites*; though it contains ſuch powers, that, under a due doſing with other matters, may contribute ſomething towards the eduction of both ſilver and *gold*.

From the ſeveral proofs I have made of a variety of *pyrites* from different parts of Germany and Hungary, I have found, that the ſort yielding *gold* have had either tender and unobſerved eyes of richer ores, eſpecially rich ſilver-ore, or ſpangles of native gold, or ſome *quartz* (in which gold generally lodges, and not in *pyrites*) entangled and mixed with the ſample under examination; and therefore, before ever the ſample be beat quite fine, and committed to the furnace, it is highly neceſſary carefully to inſpect it both by the naked and armed eye, and to omit making no experiment that may contribute to diſcover it, as *gold* may lie concealed in the tendereſt ſpangles and duſt: as (1.) ignition, whereby the *gold* is not only heightened in colour, eſpecially when it happens to be ſmutted,

or,

or, by means of a mercurial admixture, overpale, but to break and crumble the ſample which is commonly *quartzy*, and thereby to expoſe to view more ſides of veins, where the *gold* commonly lodges; and the *pyrites*, for which the *gold*, being ſo crude, cannot always be diſtinguiſhed, becoming dark, the *gold* muſt needs ſhew to the greater advantage: (2.) amalgamation, on which the moſt ſkilful hands ſhould be employed, as the *gold*, being in ſuch tender ſpangles, is apt to float on the water: (3.) *aqua regis*, which is ſtill better, taking the ore crude and unroaſted: laſtly, the repeating the proof; when the difference of yield muſt at leaſt ſhew the *gold* either accompanying, or lodged in the *pyrites*.

The following remarks may here be juſtly made; (1.) that as no great ſtreſs is to be laid on the cubical or marcaſitical, as little is there on the round figure of the *pyrites*, for their *gold-yield*: (2.) that the pale-white colour of *pyrites* ſhould be no prejudice againſt our examining them for *gold*; nor its yellow colour, either that eſſential to its *mixtion* (ſuch as the *copper-pyrites*) or ſuperficial only, from an external *weathering*, be any prejudice againſt their *gold*: (3.) among all the ſorts of *pyrites*, I have never met with any containing *gold* alone (namely, in an *ory*, pyrity ſtate) without ſilver, a circumſtance worth our greateſt attention; and it may be doubted, whether there is an inſtance of a ſingle *gold-ore* in nature: (4.) that there is no *pyrites* whoſe ſilver does not conſiderably exceed its *gold-yield*: laſtly, that the *gold-yield*, of any conſequence in *pyrites*, generally amounts to a penny weight in the centner, or a little over or under; which conſtant proportion makes it highly probable, the *gold-yield* is procured from the *pyrites* as ſuch, and not

not from native *gold*, or other accompanying veins, ſeeing the proportion would, in that caſe, prove various and inconſtant; and then the queſtion will be, whether the *gold* be produced from it?

Now when there is *gold* in *pyrites*, and I would procure it, the body of the *pyrites* muſt neceſſarily be deſtroyed, ceaſing to be what it was, and in part commencing a different thing, a new production, mixtion, and compoſition; as we have a convincing inſtance to this purpoſe in vitriol, a matter not lodged in, but produced from *pyrites*.

In the firſt place, I ſpeak of ſuch deſtructions as happen *per ſe*, without the addition of other matters; for inſtance, common and corroſive waters, ſalts, oil, ſulphur, *&c.* poured, rubbed, or mixed in variouſly, though not without all material influx of the air and fire: (2.) of ſuch deſtructions as are commonly called *proceſſes*, wherein, along with *pyrites*, are mixed-in ſaline, ſulphureous, mercurial, and arſenical matters, alſo metals and ſemi-metals, which have uſually ſome effect: (3.) I would aſk, whether there may not be methods, where, from the running together fit particles, there may not, by means of action and re-action, impregnation, and conception, new ſubſtances, forms, and productions be procured; and thus ſomething of *gold* be procured, that neither was in the ſubject, nor in the additions. Now, (1.) as to the deſtructions happening without any palpable additions, and the concurrence of any other matter, which might be held as barely inſtrumental, without the ſuſpicion of any *material* influx on the mixtions, as the lead on the copel, not certainly to be regarded with the common eye of an aſſayer; the depart water, which, in its habitude

bitude and fitneſs to its ſubject body, ſhews ſomething more than a bare inſtrumentality; or, at leaſt the *aqua regis*, and the precipitant employed for diſcharging out of it again the earth ſwallowed up by it: I ſay, not reckoning theſe, the deſtructions of mineral bodies in general, and of ores in particular, not only cauſe ſeparations, but transformations alſo; not only exhibiting to view what they contain, but alſo ſome new *mixt*, a third body; and that for this reaſon, namely, that they are generally *decompounds* and *ſuperdecompounds*: and not only *compounds*, but mixts, nay, ſimple particles themſelves, which, when brought, either by the fire or air, into a ſtate of motion, activity, and conception, operate upon each other.

By means of deſtruction, the parts of the whole ſeparate in one part, and again unite in another, or let go ſome of their *mixtion*, that others may combine the cloſer; and theſe new combinations happen in the very act and inſtant of the ſeparations themſelves; as in the caſe of vitriol, which is not actually contained in, but generated from *pyrites*; as is evident, that in the production of it, the entire body of the ſulphur is excluded from communicating but a part, namely, its acid ſalt; ſo that its own proper ſubſiſtence, as a ſulphur, muſt needs be deſtroyed. The parts forming the new production are often already in the ſubject, and only a new coheſion or texture procured; frequently they are fetched from ſome other quarter, either apart, or together, and often ariſe from the deſtruction and mutual action of the parts, once ſet looſe and rubbing againſt each other. The vitriol-acid, and the metallic-earth, are both contained in the *pyrites*, and that in a large proportion, only not in a vitriolic mixtion; but the former

mer in the ſulphur, the latter not only entangled in the ſulphur, but alſo in another crude earth. In *alum-ſhiver* there is no vitriol-acid at all, but it is fetched either from the air, or generated at once by fire and air, or by fire alone; tho' fire, without air, can neither act *inſtrumentally* nor *materially*; neither is the white earth of alum procurable from the ore, nor therefore to be conſidered as a genuine production.

The water, which is in a large quantity, both in vitriol and alum, is neither in the *pyrites* nor alum-ore, conſidered in their *mixtion*, but is imparted to it either from the air, or by men's hands. The ſame alſo holds of other vitriols, produced from their own ore alone; though I cannot here recollect any but the white, and the ſort from biſmuth-ore and cobald, or from biſmuth itſelf, as I have experienced. The former contains a white, though coppery earth, which is neither from the ore, nor from the accompanying ſhivery, loamy, and *kneiſy* minerals; the latter, or the biſmuth-cobaldiſh, a green, though derivable from the ground-earth of the ſmalt-cobald-ore, as green and blue are in nature near allied; but the peach-bloom colour, nay, the purple-red, as their beautiful appearance deſerves a peculiar regard, muſt needs have their foundation in a peculiar conformation of their earths.

Thus in theſe productions, formed as much as may be *per ſe*, foreign matters, as air and fire, have an influx; often the air alone, as in the ſpontaneous vitrioliſation of *pyrites*; often the fire alone, as in the vitrioliſation of calamy; often both together, as again in the vitrioliſation of the *pyrites*, which muſt firſt paſs through the fire, and afterwards be expoſed

expoſed to the air, but properly both together, unleſs you would have a coaly or externally inflammable ſort. Air and fire are here to be conſidered not only in their *inſtrumental*, but alſo in their *material* capacity; or if they muſt be called *inſtruments*, *immanent* rather than *tranſient*.

The air chiefly manifeſts its virtue on, and ingreſs into the bodies of plants and animals, as in good part not only being derived from it, and remaining under its influence, but as being of a ſofter texture; nor can minerals, leaſt of all the ſulphureous and bituminous, reſiſt its action: nay, theſe are chiefly the bodies on which it performs deſtructions, ſeparations, and new combinations, as ſufficiently appears from vitriol and alum. In the *depths* of the earth it operates on minerals more powerfully than at the *day*, as being not only more actuated with a greater number of ſaline particles, but not ſo ſubject to be diſſipated by the action of the wind and ſun, conſequently it has time and leiſure to eat into veins and rock; nay, to deſtroy ſuch bodies as, expoſed to the open air, remain untouched, or become ſtill harder, and more durable. It not only penetrates, but at the ſame time adheres to what it penetrates, with its fatty, ſaline, earthy and watry particles, which laſt are the vehicle wherein the others lodge, and are introduced and incorporated into the ſubject. The fatty and ſaline nature of the air cannot be diſallowed by any one, conſidering its meteors, in particular, thunder and lightning, the habitude of pot-aſh thereto, the corroſibility of iron and copper therein, *&c.* Only 'tis here to be hinted, that we do not extend too far the action of the acid of the air to the vitrioliſation of *pyrites*, as being what is already plentifully preſent in the ſulphur of the *py-*

rites; a deſulphurated *pyrites*, and an exhauſted *caput mortuum*, never yielding any vitriol.

Fire, which conſiſts in the quickeſt degree of motion and incaleſcence of inflammable, fatty particles, imparts to the mixtion, partly from its own matter, partly from the flame of coals, wood, *&c.* applied externally, or from both together, ſomething eſſential and material, that either before was not at all, or not in ſuch mixtion and form therein; as appears from an incinerated regulus of antimony, which proves heavier than it was before ſuch incineration; and from all the transformations of bodies containing any thing inflammable, which by the external fire is ever made the object of its own rage.

In all theſe diſſolutions, new forms, or new productions, frequently occur, where ſeparations are ſeldom ſeen; yet where deſtructions happen *per ſe*, and are purely the effects of air and fire, without any thing beſides, there we may rather expect ſeparations, and that in mineral bodies: and if we would proceed accurately, the ſeparations are to be verified by compoſitions. I ſpeak of mineral bodies, and thoſe both *compounds* and *decompounds*; for, animal and vegetable bodies eaſily and certainly enough ſeparate into their original earth and water, out of which they grew: and *mixts*, nay, often *compounds*, are of a nature, that the former bear not ſeparation at all, the latter, not without ſome difficulty. In ſeparations the parts of the body are already *formally* in it, what is otherwiſe produced, *potentially* only. Of the fire it is commonly ſaid, that it is unfit for ſeparations, as framing new mixtions only; that the fire is a *deſtroyer*, not an *analyſer*; that the air, on the contrary, is a better ſeparator

parator and diſſolver; but in *decompounds*, ſuch as minerals moſtly are, the reverſe may rather be affirmed; for, the fire rightly enough diſſolves the *pyrites* into its parts, ſo as ſeparately to exhibit its ſulphur, arſenic, copper, and iron; whereas the air, by the act of vitrioliſation, quite deſtroys the ſulphur, not to mention the metallic portion, which in this caſe is taken into the vitriol-maſs, and thus becomes transformed.

Now to apply this to our *pyrites*; it may juſtly be aſked, whether the *gold* be parted, or formed from it, and thus be either *formally*, or *potentially* therein? By ſpontaneous vitrioliſation a *gold-yield* is neither to be induced, nor increaſed in the *pyrites*; nay, though by theſe deſtructions there happen extraordinary precipitations of ſome earthy particles, that often partake ſomewhat both of *gold* and ſilver; yet ſuch conjectures are with difficulty proved: for, *gold-pyritæ* are either coppery, or arſenical, or participating generally of both. Now ſuchdo either not ſufficiently, or not at all vitriol iſe; and foſſile or native ochres, or *pyrites-earths*, ſeveral times aſſayed for *gold*, I found to have little or no yield.

Suppoſe now we have recourſe to the fire, and then the *pyrites* either is, or is not roaſted; in the latter caſe, it is taken crude, doſed with lead, and ſcorified, and the lead-regulus *driven*, or copelled, that is, the noble is driven or parted from the ignoble metal. Now here we procure a *ſilver-grain*, at leaſt from the lead, were there no ſilver at all in the *pyrites* itſelf; in this *grain* the *gold* muſt lodge: this *ſilver-grain* is committed to depart-waters, namely, the *gold* parted from the ſilver, and ignited, which finiſhes the proceſs. Now though

this method of working *pyrites* for *gold* ſhould ſeem to be performed *per ſe*, without any foreign additions, yet that there only happens a bare ſeparation, as no methods of coction, maceration, digeſtion, and maturation, have preceded, may prove a mere precarious aſſertion, without conſidering in the leaſt the nature of lead in its volatility and activity, the efficacy of ſulphur, and the mercurial ſeminal virtue of arſenic; eſpecially when theſe powerful agents happen to be applied to, and to find proper tender matrices. All theſe are here effectually applied, whether the operation be carried on in the way of roaſting, or of ſcorification with lead, the metallic earths exhibiting themſelves as ſo many tenderly prepared matrices: and ſuppoſing the parts of the *pyrites* to do nothing towards the tranſformation and exaltation, yet the fire acts here no inconſiderable part, not only in the way of a ſeparation, but alſo of an influx; whether by enriching the *phlogiſton*, and metalliſing the matter, or by a higher virtue ſtill, may be made a queſtion.

Whilſt I was engaged in theſe reflections, there came to my hands an extraordinary experiment of M. Homberg, from which he maintains, and with a good deal of probability, that in ſilver are contained particles of a gold-nature, which, in the courſe of the proceſs, at firſt become perfect *gold*. 'Take between one and two *marks* of ſilver, which 'being aſſayed in the uſual manner, with *aqua-'fortis*, in order to aſcertain its containing no *gold*, 'melt it an hundred times over, and having con-'tinued it each time in flux for an hour at leaſt, 'depart it; you will procure a very ſenſible quan-'tity of *gold*, which before was not to be found 'in the ſilver *.' 'Tis pity our author did not ſet down

* Mem. de l'Acad &c. l'an. 1709. p. 141.

down the weight of the *gold* procured; alſo, that he does not inform us, whether the proceſs was carried on with the ſame parcel of ſilver, and with the ſame *yield* over and over; though this cannot be, at leaſt, ſeems not credible, as may appear from his ſecond experiment, which ſhall be mentioned below, and as may be concluded from his judgement on it; and laſtly, we have not Homberg's purſe, for repeating ſuch experiments. We may, however, firmly rely on his veracity, and conclude from this, how much reaſon we have, even in ſuch mineral and metallic proceſſes as happen *per ſe*, to expect new forms and productions.

For, in the experiment before us we have no ore, but a ſimple, and every way well parted metal; no *compound*, but a *mixt*. Here we have neither ſulphur nor arſenic, as is in *pyrites*, nor lead, nor any thing elſe added: yet, how ſimple ſoever ſilver may appear, it is not really ſo; it ought to be obſerved, as appears from Homberg's ſecond experiment, that the whole of the ſilver is not converted to *gold*, but only ſome particles, which have their certain number, weight, and meaſure, and are produced all, if not at the firſt, yet at the ſecond and third trials. And what is it in ſilver, which thus is no ſilver? probably an earth.

A foreign metallic earth may be contained, to a conſiderable quantity, in ſilver, as may be judged from the univerſal mercurial affinity of metals, and particularly of iron-earth, which, notwithſtanding, cannot eſcape *depart-waters*, and often proves to be that fallacious black calx, which we take for a *gold-calx*, though in fact it is no ſuch thing: and if this earth, which turns to *gold*, be an iron-earth, may not the like, with more probability, be ſuppoſed in

pyrites-ſilver, as *pyrites* always contain iron; and *gold* be in quickſilver *potentially*, not *formally* and actually, but only in the proximate degree of becoming ſuch. Hence appears, how much depends upon time and fire, and how, from the defect of one or the other, particularly of the higheſt degree of a glaſs-houſe heat, we may after chance to miſcarry in all our deſigns; and that what we may be apt to aſcribe to extraordinary *additions* and ſecrets, may only be the effect of patience, time, and fire.

In the next place, Becher's experiment of making iron from loam and linſeed oil offers itſelf to our notice; and this leads me to conſider ſuch ore and metal-ſmeltings, where the coal and flame happen to be in immediate contact with them, as is the caſe at all huts for ſmelting-ores; this alſo gives me an opportunity of clearing up a little more the queſtion about the transformation of metals, and their mixtions; how they happen *per ſe*, or, at moſt, barely by the fatty wood-coals, and other, either vegetable or animal particles, coming to play in among them. For, though M. Lemery's reflections on this experiment ſtaggered me greatly, in regard to Stahl's opinion about reſtoring the phlogiſton, and its *material* influx on the metallic earths, nay, almoſt brought me over to be of his mind, yet I ſhall vouch for neither opinion, but leave them to ſtand or fall, at the judgement of the reader. M. Geoffroy, a member of the academy of ſciences at Paris, did, in the year 1705, on occaſion of Becher's experiment, ſtart the following queſtion, viz. *Whether it were poſſible to find plant-aſhes having no iron?* or more diſtinctly, *Whether thoſe iron-particles, actually procurable by the magnet from vegetable aſhes, were really in the plants*

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in their freſh and unburnt ſtate, or firſt produced therein by the act of incineration and burning? M. Lemery the younger, reaſoning from the poſſibility of the thing, affirms the *firſt*; as from iron being contained in all upper garden-molds, whence plants muſt derive their nutritious juices: again, from iron, by means of water, changing to a ſalt or vitriol; to which might be added, that vegetable waters may affect what a formal acid vitriol ſalt cannot; as ſufficiently appears from that macerating water, prepared for the uſe of iron-plates, from the fermented acetous juice of corn, of which we ſhall ſay ſomething in the chapter on vitriol. After this, M. Lemery ſets about examining the matter of fact, yet without alledging any one ſolid proof; only denying the allegations and concluſions of his antagoniſt, and, at laſt, anſwering his objections. M. Geoffroy undertakes to defend the *laſt*; and here he chiefly aſks, how' tis poſſible for ſuch a vitriolic vegetable juice not to affect the taſte, as a ſingle grain of vitriol may ſerve to impregnate ſeveral meaſures of water. Though the diſpute ſeems to be but lamely managed on both ſides, yet it muſt be allowed that the former has the advantage, at leaſt in point of anſwering objections, tho' not that dexterity at defending his own poſition; and that, though I have always ſuſpected the original of this iron in plants to be rather in their incineration, yet I cannot hitherto find proofs ſufficient to ſatisfy myſelf, much leſs another, about it. And here the queſtion is not, whether the iron-particles do, or do not actually lodge in the ſubſtance of the plant, the linſeed oil, *&c.* but rather, whether the linſeed oil, and the clay, or loam, do, by the operation, yield any iron, which before was neither in the one nor the other: for, M. Geoffroy readily allows, that both in the loam and oil, there is al-

ready ſome of this metal, previous to their addition, namely, *per ſe*, as appears by the magnet; tho' I doubt much, whether there be any in loam as ſuch, a pure marl-earth. And M. Lemery cannot deny, but that by the addition more iron is procured than otherwiſe would from the matters taken apart: yet neither thus is the diſpute at an end: for Geoffroy alleges that the marl, in order to its becoming iron, wants ſomething, which by means of the linſeed oil muſt be communicated to, and incorporared with it. Lemery, on the contrary, inſiſts, that it wants nothing, only ſome impediment remains to be removed: the former, that there is no iron yet, but that it muſt be firſt produced: the latter, that it is already formally therein, and wants only to be ſeparated from the foreign matters, that hinders its aſſuming a metallic form. The former, that what in the clay or loam ſtands in the way of the metalliſation, as alſo of the magnet, is an acid, which may be removed by a fatty matter, as an abſorbent or alcali; which appears not improbable, from the following circumſtances; firſt, that acids uſually reduce metals to an earthy, loamy form: again, that metals do by calcination rather encreaſe than decreaſe in weight, and thus loſe nothing, that muſt again be refunded, but rather gain ſomething.

But not to inſiſt on the acid in loam and clay; a ſmall matter therein cannot greatly contribute to fill up the pores of ſo much iron, as may be procured from it, there being more than a little acid requiſite to reduce to earth only a ſmall quantity of iron: or otherwiſe, I find not ſuch a ſimilitude of circumſtances, as to believe, that an artificial metal-earth agrees only in this with a foſſil. But it may be anſwered, which yet, I think, is not to be allowed him,

him, that when the formality of this experiment conſiſted only in removing an acid ſalt, and the vegetable fattineſs acted here as an alcali; this fattineſs, as ſuch, and in its unaltered ſtate, cannot be ſaid to effect it; but may, when in the courſe of the operation it becomes reduced to an actual aſh, and thus to an alcaline ſtate. For, oil and fat, as ſuch, remove no acid; but conſiſting themſelves moſtly of ſuch, encreaſe its quantity rather; but a lixivious ſalt effects it.

Still ſeveral difficulties offer that oppoſe a poſitive declaration from *Lemery*'s opinion.

(1.) There will be requiſite a much greater quantity of alcali to obtund a certain quantity of acid; and in loam, by his own conceſſion, there is much acid. Again, what quantity of alcali aſhes does linſeed oil afford; nay, how much pure alcali is procured from the aſhes?

(2.) Why are not metallic earths reducible with pot-aſh and the like; and *lunæ cornua*, not again to ſilver, but much, nay almoſt all of it loſt, when repeated by trials with alcali: whereas pitch, fat, roſin, and the like do, under proper treatment, reduce all the ſilver *back* to its metallic form: and yet, in the one caſe, ſuch fatty matters ſcarce in their whole ſubſtance and weight amount to ſo much, as does the pot-aſh employed in the other, tho' without any effect: and the leaſt quantity of coal-duſt reduces my *antimonium diaphoreticum*, as alſo my *vitrum antimonii*: whereas the former floats in the alcali, and under due cover and ſcreen from coal-duſt, for ever remains an earth, or goes ſooner off in fume.

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Whatever probability there may be for Lemery's opinion in the encreaſe of weight of ſome metallic calces or earths, a thing not to be denied, yet till other convincing experiments can be produced, I hold the actual cauſality, or the formality of Becher's experiment to conſiſt, not in removing matters, ſtanding in the way of the metalliſation; nor in a way of unfolding all the iron-particles already extant, but in a material influx, and an addition of parts deficient; in an eſſential communication of the metalliſing fattineſs, and thus in a real formation. Conſequently, that there is nothing in Lemery's opinion that can in the leaſt invalidate my notion; not only in regard to the metalliſation of a *gold-earth* in *pyrites*, but alſo principally, in regard to the production of *gold*, extant therein neither in a metallic nor earthy form; alſo in regard to the buſineſs of transformations, nay even tranſmutations.

To illuſtrate the deſtructions or diſſolutions, performable by *additions*, and not by air and fire alone, I ſhall here alledge M. Homberg's experiment, promiſed above. 'Take and diſſolve a 'mark of ſilver in aqua fortis, and remove what 'remains undiſſolved at the bottom of the glaſs: 'throw down this ſolution with common ſalt; 'adulterate well the precipitate, and dry it. To this 'ſilver-calx take half as much regulus of anti-'mony, well purified and reduced to a fine pow-'der: mix all well together, and being put into a 'retort, drive it in a ſand-heat, and there will 'come over about three ounces, or ſomewhat 'more, of a butter of antimony: raiſe your fire to 'the higheſt pitch, and you have the ſilver at the 'bottom of the retort, mixt with a part of the 'regulus of antimony. Put this ſilver into a cru-'cible in an open ſmelting fire, wherein let it fume, 'till it can no longer, or till the regulus be entire-'ly

'ly gone off. Melt this ſilver once more, nay 'twice, with a little borax and ſalt-petre, and it 'will prove as fine and ductile as a teſted ſilver. 'Then granulate and diſſolve it in aqua fortis, and 'you will have a number of ſmall black flocks, 'which being melted, prove to genuine *gold*. Re-'peat this with the ſame ſilver a ſecond and a third 'time, and you will always procure ſome black '*gold* calx. In the firſt proceſs, the particles, 'which are proximately fitted to become *gold*, be-'gin to be perfect, and fall down as ſmall black 'flocks. In the ſecond, there are ſome more pre-'pared and perfected; and in the third, none at 'all: when it appears, that the particles, fitted to 'become *gold*, are by the two firſt operations 'quite exhauſted, or drained out of the ſilver.

'Here it may be objected, that the regulus of 'antimony *(regule de Mars)* has produced or 'educed this black calx from itſelf: if ſo, there 'muſt as much be procured in the ſecond and 'third operations as in the firſt: whereas in the ſe-'cond, there is not ſo much as in the firſt, and in 'the third, none at all. To this add, that we 'very often meet with grown, native *gold* in the 'earth, much paler than a fine ſort ſhould be, yet 'without yielding the leaſt ſilver, and which, by 'a repeated ſmelting, begins to become perfect, 'and to attain its due colour. Thus we find in 'ſilver a matter that turns to *gold*; and in *gold*, a 'a pale (blanchatre) matter, which by the fire gains 'the genuine *gold* colour. Theſe are the two mat-'ters, which are a middle metal between *gold* and 'ſilver, but which remain not long in this ſtate, 'being by each ſmelting brought ſtill more and 'more to the perfection of gold *.'

* Mem. &c. l'an. 1709. p. 142, ſeq.

This

This experiment afforded me a double pleaſure; *one*, as it is ſo much adapted to our preſent enquiry, and may yield no ſmall matter of reflection to thoſe, who, while they attend the buſineſs of ſeparations, overlook that of introduction: *another*, and not the leaſt circumſtance, is omitted, but which is very needful for the information of the curious imitator; eſpecially as it attributes to the ſilver, what one might be apt to aſcribe to the regulus. As in ſilver, not indeed in all, ſomething may lodge, which by certain *additions*, may be educed from it, ſo the ſame may with probability be affirmed of ores: and here the *additions* may be made in three different ways; either with other ores, with metals, with unmetallic earths, or with ſulphur or arſenic, or both together, under a proper previous preparation: not to mention at preſent ſalts and ſharp acid waters, which are foreign to our preſent deſign.

(1.) Ores may not be ſo well adapted, unleſs previouſly one of them be made receptible, and thus fitted and prepared; or be, in regard to the two middle-minerals, ſulphur and arſenic (the two grand mineraliſing matters) of a different nature and habitude: for, not only do thoſe volatile bodies operate on each other, but the arſenic may, by means of its ſtanding the fire longer, wait the deſulphuration of any other ore, and into this introduce its own naked hungry earth; unleſs by an undue degree of fire its efficacy happens to be deſtroyed; or a fit metal lodging in the one, with which appropriated earths may be brought into mutual action, they are both loſt.

(2.) I

(2.) I find metals better fitted for *additions* for *pyrites*, and theſe not ſo much in their metallic as earthy form, ſo they be otherwiſe adapted to the ſubject.

And, (3.) Earths ſeem of more importance than we commonly imagine, from the prejudice of conſidering them only as dead, inefficacious bodies: for, tho' we may not always allow them activity, yet a paſſive receptibility we often may.

I know of earths, not only devoid of all *gold* or ſilver, but of any other metal, yet combined with *pyrites*, yields ſilver in a proportion never to be found in *pyrites* alone. There are earths, looked upon as dead and effete, which in obvious circumſtances, particularly phoſphorus, manifeſt the greateſt degree of activity. What are ſalts other than productions from earth, only that they appear not in their ſaline form in all operations: and ſalts and earths are ever mutually convertible; ſalts turning again to earth, as is a known caſe. And M. Roſinus of Munden ſent me a white cryſtalline ſalt, greatly reſembling a Glauber's or an Epſom ſalt, and prepared from a ſort of ſtone, without the addition of any ſaline matter: which ſeems to be confirmed, from obſerving, that mineral bodies, manifeſting nothing ſaline, as biſmuth ore and cobald, much more *alum-ſhiver*, do barely by means of the air yield an actual ſalt.

Theſe things being premiſed, we are to conſider the *gold* in the *pyrites* in a threefold view:

(1.) As it is ſeen in the common way of proof, by means of lead and aqua-fortis.

(2.) As

(2.) As procurable by the aid of additions:

And, (3.) As an *over-ſhot*, or overplus, not diſcoverable in the common method of proof.

As to the firſt, I ſhall wave the queſtions relative to the preſence and eduction, and only leave to reflection, why copels, that have been in uſe, and thus are become glazed with lead, yield upon re-fuſion, more ſilver than the *lead-grain* of ſuch lead originally amounted to; and whether ever any one aſſayed his lead for *gold?* The effects of lead and cupellation, are, certainly, conſiderable; ſeeing thereby, the noble metals are penetrated ſo much, that not the leaſt of an ignoble ſort can eſcape the action thereof, but muſt needs be diſcharged and expelled: and what a degree of mutual action and re-action muſt there not beſides happen among the *pyrites*-particles themſelves, either in the courſe of a roaſting, or of the incoction itſelf?

With much more propriety may the queſtion be urged; when *gold* is procured from *pyrites*, where, by the common proof, there is none at all, or in contradiction to it, an overplus is found: inſtances of which I could alledge from my own experience. And from hence we learn, if nothing elſe, at leaſt here to diſtinguiſh what is poſſible in nature: and I have repeatedly ſaid, that it is both poſſible and feaſible to aſſiſt nature by means of *additions*, but not without labour and expence: yet after all the good hints I have here and there dropped, for working *pyrites*, minerals, and metals in this view, I cannot omit adding ſomething further: as that the gold educed in the common way

way from *pyrites*, is never formally in it; ſeeing no one ſingle metal is ever formally in any ore as ſuch, or can be ſaid to be in it in its metallic form.

Gold and ſilver can never be called *formal*, till they have attained their metallic form, and are thus become native, or, as we ſpeak, *grown*; but the metal is to be conſidered in the ore no other than an earth, which either the ſulphur, the arſenic, or both together, have penetrated, diſſolved, and drank up; or which appears barely in the form of an earth or ſtone, without any obſervable ſulphur or arſenic.

But now is this *gold* and ſilver earth, or calx, an actual metal? or more diſtinctly, does it already poſſeſs whatſoever is proper both to its ground-mixtion and metallic form? Muſt ſomething be given to it, or taken from it? We have examined this above, on occaſion of Becher's and Homberg's experiments; being much the ſame queſtion, as might regard a metal reduced to an earth by art: and I muſt needs abide by Geoffroy's conjecture in oppoſition to M. Lemery: namely, that for the metalliſation of a metallic earth, ſomething, namely, a fatty, inflammable matter, muſt be incorporated therewith.

But laſtly, how will the caſe hold with ſuch *gold-earth*, as by peculiar ways and *additions*, muſt be educed from *pyrites* and other ores? There it lodges neither formally, nor in its ground-mixtion, but muſt firſt, by the operation, be reduced to a *gold-earth*. Yet there lodges ſomewhat, as a meal, in the ore or metal, which only wants a proper ferment, and a due degree of coction; and this ferment again is an earth. This earth appears to be

be in the ſilver of the *pyrites*; particularly from the conſideration of the above-mentioned experiment of M. Homberg.

Yet, firſt, in regard to the origination of ſilver from *pyrites*, there remains the ſame difficulty, to account for the origination of *gold*. Again, we find, that where the moſt ſilver, there the leaſt *gold* lodges: nay, the richeſt ſilver-ores, as the *glaſſy*, and *red-goldiſh*, contain not, at leaſt with us, any the leaſt *gold*; whereas the contrary would neceſſarily happen, if not always, yet generally, were ſilver as ſuch, the mother of *gold*, or did ſilver contain the proximate matter of a *gold-earth*. And though native *gold* may lodge in *glaſſy* ore, it follows not, that this ore is the ſoil proper to *gold*; ſeeing matters, as has been often obſerved already, may, without the one lie near, nay, lie entangled in each other, being the cauſe or origin of the other.

Whence then are we to fetch our new-born *gold-earth?* To aſcribe it to the iron in the *pyrites* ſeems improbable; as the pure *iron-pyrites* neither yields any gold, by the common proof, nor admits of any melioration from additions. To ſuppoſe it lodged in the copper of the *pyrites*, can with as little probability be imagined; for, tho' *gold pyritæ* are uſually coppery, yet the *yield* in gold is not always in the proportion of the copper-yield; but the richeſt *copper-pyritæ*, and which on that ſcore are called copper-ore, I have always found to come ſhorteſt in *gold*.

Of the crude, unmetallic earth in *pyrites*, we know not the nature and properties, except what I myſelf have negatively advanced about it, and its vitreſcibility; no one elſe, ſo far as I know, having ever examined it, or once dreamed of its exiſtence

in

in *pyrites:* nor is it ſo very eaſy a matter to come at the knowledge of it; as it is with difficulty, or not at all to be exhibited in a ſeparated ſtate, without any new mixtion.

Indeed, *gold*, as an earth, may lie in earths: and it is probable, that metals generally have their ground-earths from crude earths only, and attain their ſpecification, or formality, from the nature of the *influent*, and the mutual action of the matters, and from the beds and matrices, their proportion and incidentality: in particular, *gold-earths* readily lodge in marly, quartzy, ſandy, and conſequently in vitreſcible earths: ſo that this crude earth of *pyrites* bids fair to be a fitly appropriated ſoil for ſuch conception and growth.

As to the efficacy of ſulphur in that caſe, there certainly lies concealed great virtue, both in the whole and the ſeveral parts of ſulphur, communicable by the operation; particularly in the metallic or copper portion thereof, which, according to Poppius's experiment, is capable of being volatiliſed and ſublimed.

But, (1.) ſulphur is not to be conſidered ſo much in a paſſive, as in an active capacity; not as receptive, but as impregnating.

(2.) I have experienced its activity, when properly applied to the incomplete, particularly the white metals and the ſemi metals, exerted more for the production of ſilver. Arſenic remains to be conſidered, which in this caſe, eſpecially in conjunction with copper, is of ſome conſequence: in it lodges an earth, a mercurial virgin earth, eminently ſuited for *gold*; as thoſe but a little converſant with Mercury muſt allow; to which no-

thing comes nearer in nature and virtue than arſenic. And I would fain know why, or whether by chance it happens, that the native *gold* in the ore of *Goldeſthal* is never found near the yellow, but always near the white *pyrites*, nay, immediately ſitting, and, as it were, glued thereon; and again, why found in *quartz* among *ſhiver?*

This *gold-earth*, which *pyrites* and other ores yield, as a formal *gold*, muſt doubtleſs be in proper weight and meaſure; and that, ſhould it belong either to the ſilver, the copper, or arſenic, not all the ſilver, copper, or arſenic, would turn to a *gold-earth*, but in a certain proportion what is fitted ſo to do. Whence I draw the following concluſion, compriſing all I have hitherto ſaid, and which deſerves to be obſerved: that if this meaſured or proportioned quantity of earth be already proximately prepared, and ſuch a *gold earth*, as only, like a *gold* reduced by art to an earth, wants the fatty proportion to its metalliſation, it is educible by ſeparation in the common way of proof, without any further treatment: but if not an actual *gold-earth*, but muſt firſt be reduced to ſuch; we cannot in that caſe ſay, *pyrites* holds *gold:* and ſhould more than two different parts of *pyrites*, nay other foreign matters employed, contribute to the ground-mixtion of ſuch *gold-earth*, we muſt the rather adopt the terms, *introduction*, *production*, *tranſmutation*, *&c.* and drop that of ſeparation.

It need not be wondered, that I have dwelt ſo long on this queſtion, as it includes another; *viz. whether art may not become aſſiſtant to nature?* And ſo far as this laſt regards not only a matter of truth, but of utility too, ſo far does the other deſerve to

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be examined into and cleared up. But ſhould it at length appear to be a thing impoſſible to enrich ores and ennoble metals, this uſe at leaſt we may reap from it; *viz.* to learn not to throw away our labour and time to no purpoſe: on the other hand, ſhould we find ſome degree of melioration attainable; this would not only encourage us for the preſent, but be an incentive to us for the future to proceed further.

CHAP. XIII.

Of the ORIGINAL PARTICLES, or of the PRINCIPLES of the PYRITES.

WE have hitherto treated of the mixed and compounded parts of the *pyrites*, as (1.) its iron-earth; (2.) copper-earth; (3.) crude, unmetallic earth, with which the two firſt are ever entangled; (4.) its ſulphur; (5.) arſenic, and the ſandarach thence procurable; (6.) the ſilver; (7.) the gold in the *pyrites*; all theſe are to be found in the *pyrites*, though not in equal regard or conſideration, ſome being eſſential or conſtituent parts, others incidental only, and without which the deſtruction of the whole either may, or may not be effected. The proper ground-parts are an iron-earth, and ſomething that is volatile, and that either ſulphur or arſenic; all the others, namely, the copper, gold, and ſilver, are incidental, as the *pyrites* is often found to be without them; but as the proportion of the copper is often found to exceed the iron-earth in weight, it is neceſſary to take a view of it in another light: yet, as the copper riſes and falls, nay, may be quite wanting, it might indeed be removed from the claſs of incidental, and brought nearer to the firſt order of parts; but to diſtinguiſh it in ſome meaſure from the parts, both of the firſt and ſecond order, it may be aſſigned a middle rank, and be called a ſecondary conſtituent part of the *pyrites*.

What

What we now propoſe is, in ſhort, to learn what particles the iron, copper, crude-earth, ſulphur, arſenic, gold, and ſilver in *pyrites* conſiſt of. Speculatiſts, ever fond of enquiring into what is called the principles of things, may be apt to think we ſhould have ſet out with, inſtead of having poſtponed 'till ſo late this enquiry. Theſe preposterous enquirers into nature, ever at the entrance upon their diſquiſitions, fall to explaining the principles of their ſubjects, before they have once duly examined their mixt parts, much leſs their forms, proportions, habitudes, connections, diviſions, productions, *&c.* To lay ſo great a ſtreſs on things quite out of the reach of our ſenſes, as principles, in truth, are, and overlook what our ſenſes are proper judges of, is but the high road to endleſs conceits and imaginations; one ſingle propoſition, fairly deduced from experiments, being far preferable to, and more valuable than all thoſe imaginary theories, which have neither experiment, nor other ſolid foundation for their ſupport: and though it may not be unuſeful to reaſon about things, yet we ſhould proceed in ſuch a manner, that the reader may be led, as by a clue, from the proximate to the remote principles, from the mixt parts to the ſimple, and thus in a retrogade order, namely, that in which we treat the ſubject under experiment.

Now, if we would take all the parts educed from *pyrites* in the largeſt view poſſible, theſe either exiſted already in the mixtion thereof, and thus are actually ſeparated, or are new-produced in the act of ſeparation, or rather of the deſtruction of the *pyrites*, or elſe they exiſted in the *pyrites* in diſtinct parts; the former are iron-earth,

copper-earth, crude-earth, ſulphur, arſenic, gold, and ſilver, all which we have again divided into eſſential and incidental parts: of the latter, or the parts new produced, we have only one inſtance, namely, vitriol, yet it may be queried, whether to this laſt ſort might not be added ſandarach, as ſulphur and arſenic, whereof ſandarach conſiſts, eſſentially and corporally exiſt in *pyrites*, not in an united, but a ſeparated ſtate, though not coming up ſo fully as vitriol to the caſe. And it might be further queried, whether the gold and ſilver in *pyrites* were actually, or corporally and formally, tho' in a ſeparated ſtate therein, and not new produced, eſpecially by means of *additions*.

Should we abide by the eſſential parts of *pyrites*, namely, the iron, ſulphur, arſenic, alſo the copper, the *pyrites*, in the ſtricteſt ſenſe, is not a *mixt*, or a body made up of ſimple parts; nay, not a *compound*, or a body put together of *mixts*, but a *decompound*, namely, put together of *compounds*; and accordingly the queſtion ſhould ſeem, not to regard the original particles of the *pyrites*, but the original parts of each part of the *pyrites:* but as this would carry us too far, and eſpecially as I conſider not theſe parts as ſuch, but only as parts of the *pyrites*, we not only may, but muſt enquire into its original particles, as a compounded body; and *pyrites* being a *decompound*, the queſtion is, whether the compounds, as the ſulphur and iron were actually and formally preſent when the *pyrites* was formed, or whether theſe compounds firſt exiſted in the act of formation and production; or, what to many may appear more diſtinct, whether the formation of the *pyrites* be a *compoſition*, or a *mixtion?* where, by the former, the parts muſt actually exiſt, but by the latter firſt begin to exiſt.

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We are here not to conſider nature under the notion of a builder, who collects and prepares his materials, but rather as forming *mixts*, in the courſe of the compoſition itſelf; or, in the courſe of the decompoſition, *compounds*; and, in the courſe of the formation, forming new materials, not exiſting before; and even by means of deſtruction, which readily happens not without new productions; though ſome, from experiment, might maintain the contrary: as it muſt be allowed, ore may be prepared and formed by art, from parts already mixt and compounded, as metal and ſulphur, yet no conſequence can be drawn from art to nature; though, ſo far ſhould ſeem probable, that nature and art may proceed in the very ſame manner: and I have made ſeveral experiments, in the view of mineraliſing metals, which I ſhall here communicate.

A proper ore conſiſts, proximately, in a metallic earth, ſulphur, and arſenic (either one, or both together, of theſe two volatile matters) to which may be added a frequent admixture of an unmetallic crude earth; I mean ſuch a crude earth as is incorporated with the mineraliſed metal, or proper ore mixture, and not a kind of ſtone and mineral adhering to the ore: I alſo do not mean ore in a lax ſenſe, according to which, all ſorts of ſtone, barren in metal, ſulphur, and arſenic, are called a mineral, or ore: nor do I mean ore in the uſual notion of miners, who ſtile ſilver holding *yellows* and *browns*, ores; but I intend ſuch, where the metal is plainly and eminently ſeen mineraliſed, or reduced to an ore-ſtate: or, ore in the ſtricteſt ſenſe, is either a *ſulphurated*, or *arſenicated* metal, as *pyrites*, lead-glitter, copper-ore, tin-ore, *red-goldiſh*, *glaſſy* ores, and the like.

When I would try to make ores from metals, and, as it were, re-produce them, I cannot, for that purpoſe, employ the principles, or ſimple particles themſelves, of which they are formed by nature in the bowels of the earth, as theſe, in their ſeparated ſtate, are no objects of our ſenſes; but I am obliged to uſe metallic earths, or formal metals, alſo real ſulphur and arſenic, in order either to *arſenicate*, or *ſulphurate* the former, and thus bring them to the form of an ore. In ſome inſtances I have hit tolerably well, in ſome but indifferently, and in others not at all, as will appear from what follows.

(1.) From ſome univerſal earths, which neither are, nor were actual ore or metal, metals may be made; for inſtance, from foſſile calamy, iron, indeed in no conſiderable, and zink, in a large quantity; not only when the proper body, wherein it may incorporate, namely, copper, is expoſed to it, but even without the addition of metal, barely upon the application of the metalliſing, fatty matter, with proper care and attention, that the matters be not burnt out and reduced to aſhes.

(2.) From metallic earths metals may again be made, and, in part, ſuch as they already were, as from lead-aſh, tin-aſh, *&c.* lead, tin, *&c.* namely, by re-incorporating the fatty, metalliſing ſubſtance, or *phlogiſton*, which operation is called *reduction*; partly, what they were not before, as ſufficiently appears both from gold and ſilver, which may, in different manners, be educed from different incompleat metals, and ſemi-metals, particularly, biſmuth, tin, regulus, lead, and quick-ſilver.

(3.) From

(3.) From univerſal crude earths it is with difficulty that ores can be exhibited, the contrary of which one might be apt to imagine from the opinion of ſuch earths being the *mother* of ores, and the ſulphur and arſenic with their coction, the *father*, or impregnating principle. Examine the matter, as I have repeatedly done, but in vain, with ſulphur, a thing otherwiſe powerful and efficacious, on well purified and prepared ochre, which already, along with ſulphur, was an ore, that is, a *pyrites*; or if you ſuſpect it fallen, by the vitrioliſation, to a form quite irreducible and foreign to the deſign, take ſlime, marl, loam, clay, and leaving out the tendereſt, unchangeable, and mildeſt earths, try any how, with ſulphur, to accompliſh an impregnation of ore: though it cannot be denied, that to the production of metals, particularly of iron and ſilver, by means of ſulphur, not only the earth of one of its parts, namely, its fatty portion, but of its whole ſubſtance, is really fitted; as, by a due degree of appropriation and incaleſcence, it is not only made operative, but, by a proper length of time, may be made permanent; but this laſt operation requires the hand of an able maſter.

(4.) From ſome metallic calces, or earths, that were actually metallic, ore may be again made, as appears from the genuine *glaſſy* ore, which, from the ſaline ſilver-calx, when ſmelted along with ſulphur, nay, ſoftly, and for a continuance thoroughly warmed therewith, uſually appears in a *druſy* form.

(5.) From ſilver itſelf, without previous reduction to an earth, there is again procurable with the addition of ſulphur, or rather cinnabar (as the ſulphur in

in the cinnabar has more time duly to lay hold on the ſilver) ſuch a glaſſy ore, not eaſily diſtinguiſhable from a native ſort; as appears from the known cinnabar proceſſes, where uſually filed ſilver is cemented with cinnabar.

(6.) Ores may be made from the incomplete metals, and from ſemi-metals, as tin-ore from tin and ſulphur, antimony-ore from regulus and ſulphur, biſmuth-ore from biſmuth and ſulphur, cinnabar from quickſilver and ſulphur, lead-ore from lead and ſulphur, namely, where the ſulphur is in ſeparate parcels, conveyed on the metals in flux; and that the incorporated ſulphur may not be forced off again, the mixture is poured out in due time. Yet,

(7.) It is from the feweſt metals ſuch ores may be made, as ſhall reſemble thoſe from which metals were originally ſmelted, *viz.*

(8.) A factitious tin-ore, which is flakey, blackiſh, ſooty, and ſtellate, like antimony, nature no where ſupplies us with, though properly to be called a ſulphurated tin.

9. From tin (ſo far at leaſt as I have tried) no tin-ore can be made; neither can its proper mineraliſing ſubſtance, the arſenic, be brought to flux, and conſequently to the requiſite degree of activity; nor the tin duly expoſed and appropriated to it, on the ſcore of its eaſier diſſipation and incineration. As little,

(10.) Is a mineraliſed biſmuth, or factitious biſmuth-ore, found ſimilar to a native; for, though it appears ſmutted by the ſulphur, and looks fine, yet

yet it not only does not exhibit the texture, but even the appearance of the natural mixtion is wanting, by which it ſhould hold no ſulphur; though this experiment ſhould, on other accounts, be repeated, and more accurately examined.

(11.) That procured from lead and ſulphur comes tolerably near a foſſile lead *glitter*, or ore; only it is very ſmall grained, and, if not removed almoſt inſtantaneouſly from the fire, proves very ſooty and powdery.

(12.) The reduction of a metal to the form of an ore, even its native form, is better ſeen in antimony, which is procured from regulus and ſulphur, but more fine-grained than a foſſile antimony commonly is; and would certainly be more coarſe-grained, if art, like nature, could take the proper time, and the operation not be hurried.

(13.) 'Tis in the preparation of cinnabar, that is, the mineraliſation of quickſilver, that art, at length, moſt perfectly approaches to nature, inſomuch, that between a factitious and a native cinnabar, very little, if any diſtinction appears.

(14.) On the contrary, copper cannot be mineraliſed, or not ſo as to be like a native ore, for that procured from ſulphur and burnt or calcined copper *(æs uſtum)* is no longer a metal, only as it contains ſulphur, it is called a mineraliſed copper; and, after burning out the ſulphur again, nothing remains but a metal burnt out, and reduced to an earth; And where in nature do we find ſuch a ſort?

(15.) No

(15.) No genuine ore is procurable from iron, eſpecially in the form of a *pyrites*; for, as to the factitious *pyrites*, for which antimony is employed, it is in parts highly antimonial, and thus of a mixtion unlike what is native, ſeeing antimony is never obſerved to be in *pyrites*; or, it will be a ſort of ſcoriæ, or ſlags, where the iron, after the precipitation of the regulus, combines along with the ſulphur, and exhibits ſomething reſembling an ore, without appearing yellowiſh, like an ore conſiſting of iron and ſulphur, as in the *ſulphur-pyrites*. Beſides, in the abſence of the ſalts it falls not to pieces, but remains firm and laſting; and yet it is affected by the air, though not in the way of vitrioliſation, ſuch as the air uſually effects in genuine *ſulphur-pyrites*. We come ſtill nearer to nature here, when for the ſulphuration of iron, inſtead of antimony, we employ a pure lead-ore, under which operation lie concealed ſome practical truths.

Now it is poſſible there may be ſome better means of bringing metals and metallic earths back again to their native ore-form, as the ways of trial in nature are ſo endleſs, that it is not poſſible to deviſe, much leſs perform them all; we muſt not therefore, from a miſcarriage in an intended experiment, directly conclude the impoſſibility of the thing: yet it follows not, that nature, in her formation of the *pyrites*, proceeds in the very ſame manner that art does; but, from the circumſtances hereafter to be alledged, there is no ſmall probability, but that to the ground-work of *pyrites*, as of other ores in general, not *mixts*, but *ſimples* or principles contribute; that is, not matters already proximately prepared for parts of *pyrites*, but undetermined

determined juices and damps, which, by their conflux and coction, firſt of all become either iron-earth, copper-earth, ſulphur, arſenic, gold, or ſilver, as now extant in the prepared *pyrites*.

Upon a general view of the ſubterraneous ore-productions, particularly *druſe* and *ſinter*, we ſhall find three ſorts of ſtone, and as many ways of their production and generation.

The firſt is an *induration* or condenſation of dry, earthy, but tender, porous, and powdery particles, by which an earth may be baked, and become of the hardneſs of ſtone, by means of air and water, as I have reaſon to be fully ſatisfied by indubitable ſigns from the *ætites*.

The ſecond is a *precipitation* of earthy particles out of water, by means of its running and trickling down, whence ariſe the *ſinter flos ferri* and *ſtaladites*; not out of muddy, but the moſt tranſparent ſpring-waters, in which the earth lies ſtrewed up and down in the moſt tender manner, ſo as to eſcape not only the ſight, but the cloſeſt ſtrainers.

The third is a *cryſtalliſation*, where ſtoney, both flinty and ſpathy particles, intimately diſſolved and mixed in the water, like a ſalt, ſhoot out of the moſt tranſparent cryſtal waters, by means of reſt, and by length of time; conſequently, by the moſt leiſurely and unobſervable evaporation of the moiſture into formal, ſaline cryſtals; as I have fully made appear in chap. V. In this alſo Dr. Woodward agrees, with reſpect to the production of *druſe*, *mountain-cryſtals*, &c.

But

But as to ores themſelves, it is not credible that any one of the above three ways is that by which they are generated: to begin with the third; we find, indeed, ſuch, not only cryſtalliform, polygonal, priſmatical, *&c.* forms, both in ſtones and ſalts, but alſo in *druſe*, lying immediately on ſtone and bottoms, formed by cryſtalliſation, as might incline us to think both the ore and ſtone to be generated at once, and in the very ſame manner. But it cannot be conceived alſo, that metallic earths, ſuch as belong to the formation of ores, ſhould be ſuppoſed to be diſſolved by meer water, ſeeing we have neither example nor experiment to that purpoſe, as we have for the production of *druſe*.

Why then muſt things, lying upon and near each other, be ſuppoſed to be produced together, and in one and the ſame manner? When *ſinter* comes to ſettle, the *drifts* and ſhafts, where it is uſually produced, are not full, but empty of water; but cryſtalliſations happen not without water: and from ſight we learn ſuch apertures to be as ſeldom, after the generation of the *pyrites* on the *ſinter*, full of water, as before in the generation of the *ſinter* itſelf they could poſſibly be.

As little can the ſecond way be genuine, whilſt, as was ſaid, common water is incapable of bearing up ſuch heavy particles as the metallic are; I will not ſay in ſuch a degree of diſſolution and rarefaction, as there are no inſtances to ſupport the aſſertion, but in ſuch quantity as would be needful for the production of the ſuppoſed ore; ſeeing, by the leaſt degree of reſt, they ſhould ſeparate again like a ſlime or *ſludge*. In a word, between water and a crude

crude unmetallic earth there may, indeed, be ſome, but between water and a metallic earth, no analogy; but the latter may by means of middle ſubſtances, *viz.* ſalts, as appears from the effects of ſharp, corroſive waters on metallic earths, be appropriated to each other.

Laſtly, as little can pure induration prove of any conſequence here, if, amidſt many other circumſtances we again only conſider the beds and figures of *pyrites* on *druſe* and *ſinter*.

But there are ſome ſtrong reaſons againſt imagining the generation of an ore to reſemble the ſpringing of a plant out of the earth; one is, that then we muſt expect to find in the ſtone or rock the roots, and, by their means, a connection of the ore with other matters, as its origin; but of this we find not the leaſt trace either on *druſe* and fiſſures, where they often lie as looſe as if only glued thereon by one end, or in the firm rock or ſtone. But the generation of ores rather happens *damp-wiſe*, as I think I have ſhewn in chap. V. I ſhall only repeat one thing, that from hence, in particular, it appears, why the ores, ſtanding on *druſe*, generally preſent one ſide only, namely, where the *weather* or damp beats on them like a driven ſnow.

Theſe ore-producing and ore-conveying *damps* may, both in their original and incidental matters, not happen to be of one and the ſame mixtion and influx; yet it is not ſo neceſſary to ſuppoſe a very great variety of them, ſeeing it is poſſible, from the internal coction, the length of time, the beds or matrices, to aſſign a reaſon, why from one and the ſame damps different productions may ariſe.

The

The beds or matrices are, undoubtedly, in ſome degree, pre-requiſite; for, though almoſt each ſort of ore be to be met with, conſequently generable in various ſorts of ſtone and earth, for inſtance *pyrites*, the univerſality of which is indiſputable; *red-goldiſh* ore, which is to be found on quartz, ſpath, ſhiver, *&c.* lead-ore, not only in theſe, but in lime-ſtone, and other minerals; tin-ſtone in quartz, ſpath, Muſcovy-glaſs, and clays; and we are ſtill far from having made ſuch diſcoveries in the bowels of the earth, but that many more may remain concealed; nay, probably, ores may be diſcovered in beds where they were never ſuſpected to lodge, in particular, quartz, horn-ſtone, *&c.* which are the firmeſt bodies, prove to be univerſal matrices of ores: yet here it holds not as of the matrices of animals, which are abſolutely neceſſary, and contribute materially to the birth.

This is manifeſt from experience: however the difference of beds may contribute ſomething to the generation of ores; for, otherwiſe, why ſhould *lead-glitter* be, if not quite a ſtranger, yet rare and thin ſown in *ſhiver*, whereas *pyrites* is almoſt univerſal; and why ſhould tin-ſtones never be heard of in ſhiver? But we are not always to form a judgement of the truth of this propoſition from *mixt-work*, where ores and minerals are ſeen mixed together in a ſurpriſing manner; but then it is in places where two very different veins happen to croſs each other.

In like manner, ſuperfoetations muſt not be totally rejected, particularly, where ores and minerals are diſpoſed in layers, one on the other; and where, not the undermoſt ſtone or rock, but each layer,

layer, muſt be conſidered as the matrix of the next above it. Beſides, it is not to be denied, but that there are beds, or rather productions, where, according to all appearance, the under and over layer contribute neither poſitively nor negatively to the production of *pyrites*; that is, neither promote nor hinder it, but the *damps* contribute all; nay, even to the firſt earth of Becher, and thus to the ground-work of the ore.

Leaſt of all is nature to be here conſidered as a common mechanic, who has all his materials ready prepared, and only puts them together: for, tho' the *gurs*, or mineral juices, and *ſinter*, among which are claiey and ochry matters, are, and may be matrices, yet ſuch marly, ochry mineral juices muſt not be ſuppoſed to exclude other earths and ſtones.

In a word, ores certainly have a matrix; firſt, a fitly adapted place; again, a matter not quite dead and motionleſs, but emitting its efficacy and emanations on ſomething, or at leaſt is a receptive matter. In and upon ſuch earth and ſtone may ore and metal be produced, but neither can ſuch earth or ſtone themſelves turn to ore or metal; which matrix, whether the ſtoney or earthy, contributes more material damps, is a queſtion not ſo eaſily reſolved: the anſwer, however, ſeems to favour the laſt more than the firſt; as what is tender, ſoft, and yielding, is more fitted for the change happening here, than what is cloſe, hard, and ſtoney.

But in all theſe *out-weatherings*, or exhalations, either from the under or upper layers, either porous, ſlimy or cloſe; that is, either earthy or ſtony

matrices, the affair principally depends on the *inweathering* or inhalation, for the production of an ore, particularly *pyrites:* which *inhalation* only conſiſts in damps, fumes, vapours, *&c.* ſeeing, from the conſideration of *druſe* covered over with *ore* and *ſinter*, neither induration, precipitation, cryſtalliſation, nor vegetation, can have any place.

Theſe damps are mineral, yet not of an ore and metal mixtion, but, proximately, fitted for ſuch a mixtion. They muſt be of different forms and mixtures, conſequently of different powers and virtues; as the buſineſs of mineraliſation cannot depend on bare coction, or the nature of the matrix or bed; namely, ſubtile earths, which, in certain places, proportions, times, degrees of warmth and coction, become in one place lead, in another tin, *&c.* and when once prepared, remain unchangeably the ſame, tho' indeed ſubject to *weathering* or deſtruction.

In general, mineral damps have the following origin and nature; they proceed from all manner of bodies, either animate or inanimate, though from the former in greater plenty; not only from porous and looſe bodies, but alſo from the cloſeſt and heavieſt bodies, even from firm ſtone, of which we have an inſtance in the magnet. Some bodies or matters evaporate, barely by a diminution and diſſipation of their entire ſubſtance, as pure water, volatile ſalts, brandy, camphire, phoſphorus, *&c.* Other bodies evaporate by an abſtraction and ſeparation of their highly ſubtile particles from the more cloſe, coarſe, and earthy parts; for inſtance, a ſaline or earthy water, either ſpontaneouſly or artificially. Others again exhale, by a deſtruction both of their texture and mixture; as appears

pears from the volatile ſalts procured from the corrupted parts of animals, and the acid of beer. This deſtruction is in the vegetable kingdom called *fermentation*; in the animal, *corruption*; and, in the mineral, I find no better term to expreſs it by than *weathering*, or diſſolution.

The matters conſidered as exhaling, are either purely watry, as pure water and brandy; or watry-earthy; as wine, beer, vinegar, oil, and ſlimy, ſaline, and bituminous waters; or earthy-watry, as wood, bones, gums, ſalts, ſulphur, bitumen; or laſtly, almoſt pure earth, if not entirely earthy, as crude and metallic earths, ſtones, ores and metals.

Now, as evaporation is a kind of motion, and motion implies an impulſe; we here find as impellents, air and fire, which muſt animate, as it were, and make natural mixt bodies evaporate, or they would otherwiſe remain at reſt and motionleſs. Air certainly is a capital inſtrument in the buſineſs of evaporation, as being of itſelf not only ſufficient, but better fitted for the purpoſe without actual fire; whereas fire cannot ſubſiſt without air: and the diſſolutions, malaxations, ſeparations, purifications, and new productions, *&c.* by means of air alone, prove quite different from thoſe procured by fire. Yet air, which is in itſelf cold, and neither at all times attempered by the ſun, nor by a particular ſort of weather and wind, may be aided in its effects, when you would have it a proper, efficacious inſtrument, if not by an actual fire, yet by a due ſcreening. The air operates from within outwards, whereas actual fire only externally: air alſo takes up more time, and thus makes purer and more laſting parts. It, indeed, carries along with it foreign

matters, but ſuch as are more tender, flowing, and ſimple than the coarſe, ſooty, ſtubborn, and earthy particles of fire, which in open or chinky veſſels mix more of the flame with the ſubject. The principal effect of the air here is by its tenderly mixing the ſubtile, dry parts with the moiſt in a cloſer manner than can be affected by the fire.

In regard to mineral damps, particularly thoſe for the formation of the *pyrites*, three things are to be conſidered.

(1.) Of what they conſiſt.

(2.) Their origin, and the manner of it.

And, (3.) How they become *pyrites*.

As to the firſt, namely, in what the *pyrites* damps conſiſt: we are not to ſuppoſe the univerſal air-particles, as the proximate matter and ſeeds; ſeeing this would be going too far back: neither on the other hand, are we to conclude them to be ſuch mixtures, wherein the parts of the *pyrites*, namely, the ſulphur, arſenic, iron, *&c.* are formally and ſubſtantially contained. But rather taking the mean, to ſuppoſe them to be damps of a middle ſubſtance, not common to all the three kingdoms, nor formal parts of the *pyrites*, but a kind of fatty, tough glue.

Here we muſt readily allow, (1.) That the proximate and firſt ſeminal forms of the *pyrites* may conſiſt in crude unmetallic earths.

(2.) That crude earths are in their mineraliſation and metalliſation, primarily appropriated to iron,

and

and ſecondarily to copper; as by deſtruction theſe two metals are uſually very eaſily reducible to ſuch earths; not but that they may degenerate (tho' not become of another ſpecies) from the unkindlineſs of the ſoil and other circumſtances. And theſe damps are to be conſidered as different as the ſeveral *pyritæ* themſelves are, and as univerſal as the *pyrites* itſelf is.

As to the ſecond thing, namely, whence theſe damps, or the ſeeds of *pyrites* ariſe; we have three things to conſider here.

(1.) Dry bodies, as earth and ſtone; only the parts of the former lay ſpongy and looſe on each other, but thoſe of the latter baked firm; and, at times, ſeem as if run or melted together: whence ſtone may be produced from earth, and earth again from ſtone. Now the queſtion is, whether theſe laſt exhale.

We have three ſorts of ſtone; namely, marl-ſtone, lime-ſtone, and flint-ſtone. Marl-ſtone, which has ceaſed to be an earth, and commenced a ſtone, not only crumbles in the air, but proves a good manure for vegetables; various inſtances of which I have mentioned in my *Flora Saturnizans*; particularly, one from Oberau in Miſnia, which ſufficiently ſhews the affinity between the vegetable and mineral kingdoms. But for this ſtone to contribute any thing to the growth of plants, it muſt be reſolved, whereby the reſolving moiſture of the air does not ſo much crumble its earth, as rather extract ſomething from it; not take it up as a fine powder, but ſwallow it up in ſuch a manner, that the earth, by means of the water, is no longer an earth, and as little a water, but a third kind of

glutinous ſubſtance, ariſing from earth and water; which by vegetables is drank up in the way of a vapour: and the ſame matter, in order to ſerve to the growth of ores, muſt have both its firſt riſe and propagation vapour-wiſe.

Crude, unburnt limeſtone ſeems alſo ſubject to *weathering* or reſolution, and in the ſame manner: the *ſtalactites*, *dropſtone*, or *ſtone ſinter* of *Friberg*, to which the *iron-blooms* are alſo referable, is a ſort of lime ſtone. This limy ſubſtance is derived from a tender earth, ſuſtained and carried along by pure water, from which it ſeparates in proper time and place, and falling down collects gradually, and turns to the hardneſs of a ſtone. Now, as the water lets it fall, it is plain, it is ſomething incidental to it, and ſomething that it muſt have licked up ſomewhere in its paſſage. A like inſtance, not a little confirming this opinion, we obſerve ſometimes on walls, plaiſtered over with lime, as in large aqueducts; for inſtance, that called the *halſebrucke* at Friberg, and in thoſe arches built in mines for ſtrengthening *ſhafts* and *levels*; where it evidently appears, that the *ſinter*, hanging down from theſe walls, comes from the lime; or rather, that the lime, even after being burnt, ſlacked, and no longer quick and capable of conception, is, notwithſtanding, ſtill fitted for reſolution, and capable of being abſorbed by the water in the tendereſt manner; only with this difference, that this *wall-ſinter* is not near ſo firm and hard, but remains always very ſpongy and flaky. Now, here we cannot ſo very expreſly aver, that ſuch earth is looſened by a *weathering*, and afterwards incorporated with the water; but that this rather happens, as we muſt at leaſt allow of *wall-ſinter*, by means of a ſoft flooding; tho' in regard to the genuine groove-drop-ſtone, from its particles being ſo intimately mixed with the water,

ter, as by a kind of extraction, there muſt be a weathering or reſolution to precede the flooding and extraction. Yet, amidſt all our uncertainty about this matter, we obſerve lime-ſtone to be ſubject to deſtruction and reſolution, from which come highly ſubtile earths, which, as here, may change to a formal ſtone, and in other circumſtances, to different other productions.

The nature of *quartz*, or flint-ſtone, ſeems entirely impregnable and laſting; yet thoſe *druſe* and *quartz*, which appear, as if gnawed and nibbled by mice, ſeem to admit our calling their indeſtructibility in queſtion: and, I muſt own, this ſort of ſtone may contribute ſomething to the production of ores, as it is ſo eminently adapted for that ground-earth, called the ſtony and vitreſcible, by Becher.

(2.) In the depths of the earth we have collections of ſlimy, ſulphureous, and ſaline waters, whence damps, vapours, and exhalations may ariſe, which may greatly contribute to the production of ores; from an internal incaleſcence and fermentation, as it were, theſe matters exhale, and in conjunction with other vapours, become proximately adapted for the generation of all manner of minerals.

(3.) Ores themſelves exhale, of which we have palpable inſtances, tho' my experience extends only to four ſorts, which exhibit any ſuch change on the ſurface of the earth.

But this is not required of all; ſeeing (1.) ſeveral ſorts of ores may be produced, tho' not ſeveral bodies, *weathered* or reſolved for the purpoſe: as the reſolution of a *red-goldiſh* ore is not requiſite to the production of an ore of that ſort, but a quite dif-

ferent ſort, according to circumſtances, may be produced from the damps ariſing from this ore.

(2.) As in the bowels of the earth, quite other cauſes and circumſtances may concur, by which all ores, and ſuch as we find unaffected at the day, may become ſubject to *weathering*.

Now the four, hinted at above, are alum-ore, cobald, biſmuth-ore and *pyrites*,. Cobald, when expoſed long in the heap, either in a cloſe, damp, moiſt room, or to the open air, rain and ſun, eſpecially in ſmall pieces, or a meal, becomes ſo heated, as to emit a ſharp, ſweetiſh damp or vapour from it. Hither alſo biſmuth-ore is referable, which not only generally adheres, but is alſo nearly allied to ſmalt-cobald, and uſually bewrays its *weathering* among cobald, with an efflorescence of a peach-bloom colour. Alum-ore, particularly the ſort of a woody original, and ſtill containing woody matters among it, and of a bituminous nature and quality, as the large alum-mine at Commodau in Bohemia, which takes fire in the air, after lying a little expoſed on a heap in the weather and ſun; ſo as not only violently to fume, but alſo turn to a coal, and burſt out into actual flame; for which reaſon it muſt be often daſhed with water. Stone-coal, ſo far as it is genuine, and not conſiſting in bituminous, light, aluminous matters, has not, ſo far as I know, the ſame effect as this alum-ore. And the queſtion is, whether ſuch accenſions in coal-pits are ſpontaneous, or heedleſsly cauſed from actual flame and fire.

Limeſtone appears, as was hinted above, even in its unburnt ſtate, to be fitted for *weathering*, and to bear ſomething to be extracted from it, communicable, if not to the air in form of a damp, or vapour,

pour, yet to the water, running over it. Again, it ſhews, that in calcarious hot-ſprings, it may be burnt by ſubterraneous fires even in the bowels of the earth, and thus communicate itſelf not only to the intercurrent waters, but probably, as in ſlacking quick-lime, may emit a ſaline, earthy fume, fitted here and there, eſpecially with the acid of other vapours, for all manner of mineral productions.

Pyrites is, preferably to all other ſorts, capable of manifeſting the ſubterraneous *weathering* of ores; yet the white, or poiſon *pyrites* is incapable of any ſuch ſigns in the bowels of the earth, or by any experiments in the huts, like what we obſerve of the yellowiſh and yellow. The coppery ſort, it is true, will not eaſily fume or exhale at the day, unleſs it be made very ſmall, and lie expoſed in large heaps in a proper place to weather and ſun. But the coppery waters in the grooves, having their original only from reſolved *pyrites*, ſhew alſo that *copper-pyrites*, eſpecially in the bowels of the earth, and under certain circumſtances, is liable to deſtruction or reſolution.

Theſe waters, which are commonly called *cement-waters*, are not only obſerved at Neuſol in Hungary, but alſo in many grooves with us at Friberg: and it would ſeem to me, that the more coppery the *pyrites* are, in which caſe we at Friberg uſually call them *copper-ores*, not *pyrites*, the leſs yielding they are to ſuch *weatherings*, and the firmer and more conſtant they remain; whereas the leſs copper the *pyrites* happens to hold, and the purer they are in iron, it more eaſily vitrioliſes; beſides, that we have fewer inſtances of ſuch vitriolic waters, but many of ſprings, holding pure

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iron-vitriol; as the *iron-pyrites* is not only the moſt common ſort of *pyrites*, but of ores too; ſo that, preferably to other minerals, it ſhould ſeem to be ſerviceable for yielding fumes and damps for the production and generation of new ores.

3. Some other circumſtances are here to be conſidered, by which we may have a nearer view of the manner of *pyritification*, or mineraliſation in general.

(1.) We are not to imagine theſe ore-damps, which at length end in the form of the *pyrites*, already to contain the parts of the *pyrites*, as iron, copper, ſulphur, and arſenic, but only to conſider them as a ſeed. This is matter of fact; the proof clearly appears from the enumeration of the ſeveral circumſtances above, therefore I ſhall only mention the texture of this ore, which is ſo ſmooth and even, ſo undiſtinguiſhable, ſo uniform in the mixtion of its parts, as if run or caſt together, and hence in its ground-work, of the moſt tender mixtion, and ſuch a form, as can never be imagined of damps, containing the parts of the intended whole, without forming too groſs a notion of the mineral principles.

Yet this compariſon of animal and vegetable ſeeds muſt not be carried too far, as if the body of the *pyrties*, grown from its ſeed, could from its own ſubſtance enlarge and encreaſe: but here happens, firſt, an accumulation, in the courſe of which, an elaboration commences at the ſame time; by means of which the matter gradually approaches to the intended body; and ſo long as it is ſtill receptive, or if you had rather, ſeminal and ſoft, ſo long it ſtill receives the tranſient damps, which

which it brings into the ſame ferment and coction with itſelf; and when the body begins to be compleated, which happens from within outwards, it ceaſes to receive any thing further, till at laſt it is arrived at its ſtate, or full degree of perfection, and is, as it were, finiſhed. Nor ought we more readily to believe *pyrites*, or any other ore, once arrived at their conſiſtence, firmneſs, and ſtate, to improve further; for inſtance, in gold and ſilver-*yield*, all further working is at an end, and the body continues at reſt and at a ſtand. An ore, it is true, begins again to come into motion, not indeed for its melioration and exaltation, but rather deſtruction and reſolution; as I mentioned above, and ſhall ſtill further prove in the following chapter.

What has hitherto been ſaid, may ſeem ſufficient on the head of the *original particles* of the *pyrites*; as being matters quite out of the reach of our ſenſes, and in ſupport of which we can have no convincing proofs; but the whole muſt be made out by diſtant inferences and reaſonings, and a good ſhare of imagination: nor can any very conſiderable uſe be expected from them: yet, I cannot omit taking notice of two objections, for the ſake, at leaſt, of obviating ſome prejudices, and making ſome remarks, that may not be altogether unuſeful.

(1.) It will be aſked, how water is capable of ſuch mighty effects, and the moiſture of the air, which is nothing but a pure water, of diſſolving, corroding, and *weathering* ſtones and ores? I might only, for anſwer, direct the objector to the *pyrites*, which may be ſeen to crumble and vitrioliſe barely by means of the air, without any ſharp, corroſive waters: but here I cannot forbear advancing

cing an uſeful truth, regarding the very myſtery of the art, without engaging now in tediouſly enumerating what experienced men have boaſted of common water, or rather, of what only appears to be ſuch; for inſtance, Becher, of a water drawn off from freſh clay; Caſſius, of the phlegm of aqua-fortis; others, of that from vitriol, rain, dew, and the moiſture of the air; or without mentioning the power of the air, in regard to its effects on the animal and vegetable kingdoms.

This *truth* may be ſupported, that genuine ſolutions depend not ſo much on ſtrong corroſions, as on gentle macerations; that is, ſuch ſolutions, as ſhall yield us any new extraordinary productions; as it cannot be denied but that corroſive waters may yield ſomething worth the trouble, tho' nothing extraordinary. Now, the leſs corroſive the means of ſolution are, the leſs of a ſaline nature they muſt hold; and the freer they are of that, the leſs violence they exert on, and the more they are adapted, ſoftly and naturally, to macerate the ſubject; and to this we ſhould bend our chief regards.

Thus, between ſolution in general, and maceration, there is a wide difference; in regard, that the latter is always a ſolution, but the former not always a maceration. In a ſolution by corroſive waters, the *ſolvent* and *ſolvend* become indeed one body, but not ſo cloſely united, as in maceration; for, by maceration, the *ſolvent* is ſo intimately combined with the *ſolvend*, as not only to become together an indiſcernible body, but alſo to acquire a new form and nature. Yet the moiſture of the air (tho' the offspring of other waters) has ſomething peculiar, and ſhould indeed ſeem, as it is ſaline, to have the effects of ſaline ſolvents: but properly

perly and formally it holds no ſalt, and if any be procured, it muſt be by means either of corruption or fermentation; and thus, by means of the deſtruction and transformation of the *mixtion*; or by means of a magnetiſm; and hence it is at various times of various forms, according to the nature of the body it happens to be incorporated withal.

The incomprehenſibility of the volatiliſation of earthy particles may be objected, againſt what muſt happen in the *weathering*, or deſtruction of ores for new productions: but here we muſt not underſtand an evaporation in an earthy form, as what might well be allowed to happen, tho' not prove of any ſervice to the buſineſs of the production of ores; but an evaporation in the way of a clammy, fatty, viſcous fume, wherein the moiſture has intimately drank up the earthy part. There may be intended in general a volatiliſation, of dry particles, either by the power of nature or art, yet we are well to obſerve, that there is a wide difference between undertaking ſuch volatiliſation with a body, as ſtanding in its natural crude union with other things, and as ſeparated from them. *Poppius* on *Agricola* has proved the preſence of real copper in ſulphur, and I myſelf have diſcovered formal iron in crude ſulphur. Have we not here therefore a volatile copper and a volatile iron? But take and try your copper and iron, and you will find ſuch volatiliſation a very difficult matter, or not to ſucceed at all; whereas ſuch metals, whilſt ſtill lodged in *pyrites*, volatiliſe without any art, barely by the act of deſulphuration; and nature may carry on her proceſſes in ſuch places, ſeaſons, and other circumſtances, as are quite out of the power of art to command. To come nearer to our ſubject, we know

know the principles of the *pyrites* to as tolerable a degree of certainty as is poſſible, but to pretend to ſhew them in glaſs-bodies or cucurbits, and thus reſolve the *pyrites* into theſe principles, and make them the objects of our ſenſes, is what I deſpair of ever doing.

I am, however, apt to think, my notions about the *original particles* of *pyrites* and ores in general, may go as far, if not farther than thoſe other principles; namely, ſalt, ſulphur, and mercury, æther, and air, globules and *ſtriæ*, or acid and alcali, *&c.* As to running mercury, tho' no metallic principle, yet I believe it procurable from *pyrites*. Mr. *Boyle* tells us, that ſome choice Engliſh marcaſites being worked, in order to aſſay them for gold and ſilver, did, without any mercurial *addition*, yield ſome mercury *. This may well be matter of ſurprize, as it may be what does not always happen: but, when I come to conſider arſenic, as a ſubſtance certainly mercurial, and that it only wants to be made fluid, I ſee nothing uncommon in all this. I ſhall ſay nothing of the acid ſalt of ſulphur, as what, among all the volatile things, comes the neareſt to quickſilver.

We have alſo experiments of ſome mercury being procured from oil of vitriol. Now arſenic lodges in almoſt all *pyrites*; in a large quantity in the white; in a leſs proportion always in the yellow, and often in the yelloviſh. Probably, the above marcaſites were yelloviſh, as the yellow do not ſo readily appear marcaſitical, that is, cubical: and the white, tho' ſuch a figure be not uncommon to them, are not commonly called marcaſites. And probably, the yellow and white may be fitted for mercu-

* Boyle on the producibility of the chymical principles.

mercurification. But, whether the arſenic, after ſeparation from the *pyrites*, that is, in arſenic-meal, fly-ſtone, or cryſtalline arſenic, be fit for this purpoſe, I leave thoſe to determine, who conſider incidental circumſtances and appropriations, as ſo many empty notions, and who underſtand not the importance of the difference between bodies, as ſtill in their native mixed ſtate, and as in their ſeparated.

With reſpect to the queſtion, whether ſometimes ore-veins may be found, where the ore-production is in *fieri*, and not actually formed: if this be underſtood of the accumulation of ore, there is no manner of doubt, but that ore is produced on ore; and a vein, a fibre, may be ſo filled up as to receive neither this nor any other ſort of ore-damp; and thus the vein, that hitherto was but in *fieri*, comes now to be compleat. But ore is certainly generated, and that *damp-wiſe*; but damp-wiſe productions imply ſurely an accumulation. But ſhould the queſtion regard the ground-mixtion of the ore itſelf; the moſt experienced can neither ſhew the places and neſts, where the ore-forming ſpirit broods, nor the ore in its eggs and ſeeds. Further, neither can the *gurs*, or metallic juices, whether from deſtroyed *pyrites*, *weathered* ores, or from macerated, luty, marly, ſlimy, ſpathy, and calcarious ſtones and earths, claim any place here. And tho' in this caſe our want of experience is to be lamented, yet it is probable, that after all our enquiries, we ſhall find neither eggs nor brood, but be forced to own, that *pyrites*, and all other ores, do in the courſe of the conception, or of lodging the ore-damp in its matrix, arrive to their perfection by a ſpeedy coction and maturation; if the accumulation itſelf be not the mixtion.

CHAP.

CHAP. XIV.

Of the VITRIOL from the PYRITES.

THE title of this chapter may, to many, appear ſtrange, particularly to thoſe who hear mention made of *vitriol-pyrites*, in contradiſtinction to *ſulphur-pyrites*, as we allow not *vitriol* the title of an eſſential, conſtituent part of *pyrites*, but only a new production from it. *Vitriol* is, indeed, a body formed from *pyrites*, its parts, though not united in the form of *vitriol*, exiſting in the *pyrites*, and forming *vitriol*, without the acceſſion of any other foreign body: for, though *vitriol* be not uſually produced without the action of the air, yet the two eſſential parts of *vitriol*, namely, the ſulphur acid, and the metallic earth, actually exiſt in the *pyrites*. This *vitriol* production commonly happens in the very ſame proceſs whereby the ſulphur is procured, though it uſually happens without any deſulphuration, even ſpontaneouſly: but as many *vitriol* productions have deſulphuration for their proximate ground or baſis, ſo as not well, nay, not at all to happen, eſpecially at the *day*, without the former following it, the buſineſs of *vitriols* cannot well be omitted, eſpecially as it gives much light towards a better knowledge of the nature of the *pyrites*; though I cannot be ſo full and explicit as I could wiſh, for want of proper experiments, and can now only touch on the principal matters, reſerving a fuller account of this incomparable metallic-ſalt for another opportunity: I ſhall, therefore, with all the brevity

vity poſſible, conſider three things, (1.) the nature of vitriol, (2.) its kinds, (3.) its production, from all which will plainly appear the juſtice of my title.

(1.) *Vitriol* conſiſteth abſolutely in an acid ſalt, and a metallic earth, both which are, by different methods, to be procured from it; the principal of theſe I ſhall only touch on.

Under the acid ſalt we are not to repreſent to ourſelves ſomething dry (and yet, what is ſulphur more than a concentrated *vitriol*-acid?) but ſomething fluid and aqueous; though the dry form of acid ſalts be no impoſſible thing, having, in an uncommon manner, ſhewn it from ſpirit of nitre and ſpirit of tartar, for exhibiting a pure, acid, dry, volatile ſalt. It may be ſeparated from its *vitriol-mixtion*, either, as is uſually done, by diſtillation, at firſt coming over in a white aqueous form, called *ſpirit of vitriol*, then in a thick, heavy, yellowiſh, and ſomewhat earthy form, under the appellation of *oil of vitriol*; or procured by means of an intermediate, namely, a lixivious, body, whence ariſe the known medicinal ſalts, *tartarus vitriolatus*, *arcanum duplicatum*, *ſal mirabile Glauberi*, &c. with this remarkable difference, that it is not again to be forced out of the alcali, in the ſame manner as from the metallic earth, without becoming again, by means of a new intermediate body, a formal ſulphur; when it exhibits either a *ſpiritus ſulphuris per companum*, or a *vitriol* again; as from ſulphur it ſuffers itſelf to be incorporated with a metallic earth.

Next to ſulphur and *vitriol*, it lodges chiefly in alum, in which it has received its body from a

fatty, bituminous mineral; as may be ſeen, in particular, from the woody alum-ores of Commodau, the ſhivery ores of Schwemſel, and the earthy of Belgern; but, as appears from its reſolution, alum poſſeſſes it in a quite unformed, white, ſtubborn form, moſt probably referable to a calcarious ſort. It ſometimes acquires, in diſtillation, a foreign, either a vegetable or animal fattineſs; as, when in the courſe of the operation, the veſſels happen to have cracks, through theſe the fattineſs inſinuates into the work from the fumes of the wood or coals, or when with deſign ſomething inflammable is added, and then 'tis called *ſpiritus vitrioli ſulphureus*, as the acid *vitriol* ſalt, and the phlogiſton, exhibit therein ſomething ſulphureous.

The metallic earth of the *vitriol* is procured either by means of diſtillation, and remains like a brown-red powder, a *caput mortuum*, at the bottom of the retort; to which head alſo belongs the calcination of *vitriol* in other veſſels, and for other purpoſes: it may alſo be obtained by means of precipitation, which is performed by an alcali, but, at the ſame time, earthy particles precipitating out of the alcali, a pure metallic *vitriol-earth* is not procured.

In this earth, after diſtillation, ſomething lodges that may be extracted with hot water, and has the form of a white ſalt, called *gilla vitrioli*; not to be conſidered as a third conſtituent part of *vitriol*, nor as the *vitriol* itſelf employed, but as ſomething different, a more elaborated, and thus a whiter *vitriol*; in regard it, in part, ſtill conſiſts of the ſame acid ſalt as was already drawn off from *vitriol*, and alſo it contains a portion of metallic earth,

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for the moſt part coppery, whence it is uſed as an emetic, and called *vomitoria*; I ſhall not aſſert that its contents are alſo ſomewhat aluminous, having not examined it thoroughly, though I have often ſuſpected it.

That the *vitriol-earth* is metallic, and this always without exception, its metalliſation clearly ſhews, as being performable by addition of inflammable, fatty things, nay, often happening ſpontaneouſly; when, for inſtance, the retorts, in the courſe of the diſtillation of *vitriol*, happen to have cracks, through which the fatty, fiery particles mix with the earth, which is in the higheſt glow, and thus fitted or appropriated, actually refund a degree of metalleity, and form an iron, as once happened to myſelf from a certain *vitriol*; the iron not only appearing by the magnet, but to be ſhewn corporally.

The proportion of theſe two parts in *vitriol* is generally the ſame in all, namely, in a pound of a freſh uncrumbled *vitriol*, commonly from ten to twelve loths, and thus full a third of metallic earth; four loths, or about an eighth of acid ſalt, or highly rectified oil of *vitriol*, including what is collected from the gentle evaporation of the ſpirit, and from ſixteen to eighteen, that is, a compleat half water, or phlegm, not omitting what is waſted by the foregoing open calcination, or rather drying, in the air.

The reaſon of their inconſtancy in the yield of metallic earth, is to be aſcribed either to the difference of, or admixtures in, the *vitriols*, or to the evaporation and coction of the *vitriols* themſelves; ſince many *vitriols* poſſeſs a copper and iron earth

at the ſame time, and that, occaſionally, in quite different proportions; but *iron-vitriol* and *copper-vitriol* do not agree in one and the ſame yield of metal: and 'tis well known, that cryſtalline ſalts, when paſſing through ſudden evaporations, and quick cryſtalliſations, are always more watry than others, worked ſlower, and more leiſurely; and theſe laſt, as being cloſer, more ſaturated, and rich in colour, are prepared by dyers, and the like ſort of people, eſpecially if coppery.

The form or nature of the *vitriolic* texture and coheſion, is perfectly ſaline, and therefore *vitriol* is juſtly called a *ſalt*, and, to diſtinguiſh it, a *metallic ſalt*; for, when pure and freſh, it appears tranſparent; moreover, it is on the tongue a ſaline, ſharp taſte; laſtly, it is not only the being perfectly diſſoluble in common water, ſo as the water ſhall remain clear and tranſparent (unleſs the air and warmth happen to dry it up, when ſuch a ſolution is apt to let fall ſomething undiſſolved, and the water to remain a ſmall time turbid) but it alſo paſſes with the water, in its entire mixtion, quite through the cloſeſt ſtrainers.

Yet, under the title of a metallic ſalt, we are not here to include a ſort, parable, or rather ſeparable from metals themſelves, without the addition of any thing foreign, and conſequently without the ſulphur-acid, a diſtinction fully made out by Dr. Rothe, in his diſſertation on *metallic ſalts*; neither are we to judge of it by the ſtandard or ſcale of acid and alcali, as in the artificial exhibition of *vitriol* from its acid ſalt and iron, there uſually happens an effervеſcence and incaleſcence by means of theſe two parts: nor can we admit, that becauſe alcali's effervеſce with acids, all bo-

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dies manifeſting ſuch an effect with acids, as metals do, are and muſt be alcali's.

True it is, acids ſtand oppoſed to alcali's, and are of a quite different mixtion from them; but let us only repreſent to ourſelves the incaleſcence happening, under a due treatment, between quickſilver and leaf-ſilver; here we have neither acid nor alcali, and yet the union happens with an efferveſcence: and what is ſtill more remarkable, no ſuch effect appears with filed ſilver, which is equally a ſilver with the former, even though the ſame quickſilver be employed; ſo that we ſee this effect is only owing to external, mechanical cauſes, the ſilver being beat thin, becomes the more expoſed to the action of the quickſilver, and thereby rendered more receptive, as the latter may, with more quickneſs and briſkneſs, lay hold on the ſilver, and thus, from a ſudden briſk action and re-action, an incaleſcence muſt enſue, which in a ſlower degree thereof cannot.

The appellations given the ſeveral parts of *vitriol* ſeem in general proper. The acid ſalt, which commonly appears in a fluid form, lodges either in a water, and then it is called *ſpiritus vitrioli*, or in a thick liquor, and then called *oleum vitrioli*, or it is ſulphureous, when it gains the appellation *ſpiritus vitrioli ſulphureus*, or *volatilis*, or it ſtill lies at reſt in a metallic earth, and then it is denominated *gilla*. Now here the ſeveral appellations exhibit ſomething different, and ſo are neither ſuperfluous, ambiguous, nor equipollent.

The *vitriol-earth* is either yellowiſh, or of a brown-red caſt; the yellowiſh is, either a *ſulphur* or *orange*-yellow. The *ſulphur* yellow is, in the firſt

place, both what precipitates in the boiler, and what afterwards falls down before and in the act of cryſtalliſation, alſo what precipitates from the re-cryſtalliſation of a *vitriol*; though none of theſe properly deſerve the name of an earth, or ochre, as they ſtill retain much acid ſalt; and further, ſuch earth as ſpontaneouſly precipitates from *pyrites*, particularly the arſenical, or white ſort, after corroſion or maceration by ſharp waters. The *orange*, or yelky yellow, is principally found in the earth in chinks or clefts, under the names *gur* and *ſinter*; alſo in many ſprings, particularly the medicinal, in *thermæ*, in *vitriolic* or acid waters; and from *vitriol* itſelf, when not burnt quite to a redneſs. Hither alſo is referable, on account of the name, foſſile ochre, or *mountain-yellow*; this yellow earth, uſed for colouring, containing alſo ſomething of a *vitriolic* earth; hence it alſo yields ſome metal, but ſuch as is not derived from *vitriol*.

As to the *red* earth of *vitriol*, it is called the *caput mortuum* of *vitriol*; not as if it was quite *yieldleſs*, ſince it not only contains the above *gilla*, but alſo metal, and that plentifully; but rather, as by the ſtrongeſt degree of fire, it is deprived of its ſaline, ſapid parts. It is now, as it was long ago, called *colcothar*; others denominate this *vitriol-earth*, *copper-red*; ſo far indeed not unjuſtly, as *vitriol* is commonly called *copper-water*, or as copper appears red, tho' not fundamentally enough, in regard this *copper-red* is often an iron-earth; and though it were a copper-earth, yet the former is always a beautiful red; the latter, on the contrary, a dirty and black red, nay, uſually appearing entirely blackiſh. Further, it is called *red vitriol*, or *atramentum rubeum*, but as it is only in part, and not entirely, it deſerves not the appellation, *vitriol*;

ol; though others would by it underſtand, not a thing burnt, but a foſſile matter, namely, a red *vitriolic* mineral, and would mean by it the *chalcites* itſelf, though not ſo properly to be called a red *vitriol*, as a red *vitriolic* mineral: we alſo find it called *rubrica*, which is to be diſtinguiſhed from the *rubrica fabrilis*, or *ſcriptoria*, [ruddle] uſed for drawing and writing.

In ſhort, the higheſt acid in nature, and a metal, are what conſtitute *vitriol*; the reſolution thereof evinces this truth plainly enough, and the compoſition confirms and puts it beyond all doubt.

Vitriol bears a great many names. *Vitriolum* ſeems to be derived to it from its glaſſy tranſparency and ſplendor. *Atramentum* is another appellation formerly much uſed. *Chalcanthum* was the common name among the Greeks, denoting properly a *copper-vitriol*, or rather, flowers or effloreſcences from *copper-pyrites*, or ores, under which they muſt needs have compriſed the *ſideranthos*, or flowers of iron, or rather the effloreſcence of *iron-pyrites*, as they made no expreſs mention of *iron-vitriol*, tho' in fact, the latter is more plentiful than the other, and its *pyrites* vitrioliſes ſooner. Such are the moſt common appellations of *vitriol*.

(2.) Under the head of the kinds of *vitriol* we find a great deal of ambiguity, confuſion, and contradiction, from the ſeveral appellations, *Sory*, *Miſy*, *Melantaria*, *Chalcites*, *Atramentum*, &c. which authors give us as the names of ſo many diſtinct kinds. *Miſy* is ſaid to be a yellow *vitriolic* concrete. M. Lincke ſent me, from the Hartz, a ſiſken-yellow, clear, flakey, powdery matter, under this title, conſiſting, indeed, of martial *vitriol*,

but in itſelf, or rather its flakes, containing ſomewhat of a foreign earthy nature, which, for want of a ſufficient quantity of it, I could not properly examine. As to the *etymon* of the word, I am apt to think it derives from Myſia, a country in the leſſer Aſia, and denotes a Myſian *vitriol*, and that its firſt deſcription was taken from ſomething external and incidental, namely, its yellow colour. *Sory*, doubtleſs, derives from Soria, or Syria; and as the firſt *vitriol*-ore from that country appeared externally, in its roughneſs and matrix, of a dark-grey, its deſcription was founded on that circumſtance. *Melanteria* ſhould, from its etymon, ſeem to denote a black *vitriolic* concrete. *Chalcitis* is, by ſome, held to be a red, by others, a white *vitriolic* concrete, and really is no other than a woolly and capillary ſort, and conſequently a white efflorescence. Now, it is true, we have ſuch efflorescences of a real white colour, and that on a red mineral, whence *chalcitis* is denominated red, and this is the genuine white *vitriol* mentioned by Lohneiſs; ſeldom found any where, and with us at Friberg, not at all.

But we are to guard againſt taking it either for the *trichites*, or capillary *vitriol* in general, which only appears white on account of its tenderneſs, but which, by a due cryſtalliſation, plainly enough ſhews its green colour; or for the aluminous efflorescences, appearing among and near *vitriol*, on aluminous, *pyrity mixt-work*, as is that of Braunſdorff: moreover, writers ſeem to mean by the *calchites* a *vitriol* calcined to whiteneſs. But the prevailing opinion is, that among the ancients it denoted a *vitriolic* red mineral. But whether white or red, native or artificial, it muſt needs have been an iron, and not a copper *vitriol*, as having been uſed in making their mithridate.

In

In ſhort, all the abovementioned are certainly *vitriols*, and *vitriolic* mixtures, though no one of theſe titles is properly expreſſive of their nature, all of them meaning only ſomething incidental. *Chalcitis*, in its proper ſignification, which yet is not the common, ſhould denote a copper-ore, or copper-ſtone; but being now deſcribed from its earth or ſtone, and its red colour, it is, inſomuch, referable to the incidental deſcription of the others.

As to *ſory* and *melanteria*, I find ſuch *pyrity*, *vitriolic*, dark-grey *ſhiver*, not only in the grooves, but alſo at the *day*, after having lain there expoſed for ſome time. Hither alſo may be referred the *vitriolic-ſory*-earths from other places; though under this appellation, Galen only mentions a firm ſtoney matter; as M. Berger *, in his treatiſe on the Carlsbad waters, mentions ſuch a ſort ſeen at Siena in Italy (ſo alſo does Matthiolus, in his commentary on Dioſcorides †) and compares it with the *vitriol-earth*, near Schmiedeberg in Saxony: and as to *miſy*, we find it often repeated, that *ſory* changes to *chalcitis*, *chalcitis* to *miſy*, not only by Caneparius, but alſo by others; by *chalcitis* not meaning a crude, red, *vitriolic* mineral, but the *vitriolic* effloreſcence itſelf. 'Tis true, a black *pyrity* mineral gives forth a white *vitriolic* effloreſcence, which, at length, turns yellow: nay, a *vitriol*, whether naturally green or blue, does, by means of a warm air, or a ſoft fire, not only crumble to a white powder, but alſo this powder, both ſuperficially, and at laſt throughout, turns of a yellow caſt; 'till at length, by heightening the fire, it is all changed to a red powder.

Yet

* Bergeri Commentat. de Therm. Carol. p. 197.

† L. v. c. 74.

Yet this *gilding* happens not ſo well in the groove, as at the *day*, unleſs there happen to be there dry places, or warm weather. From the Rothe-grube, at Friberg, I have procured much of this black-grey *vitriolic* mineral, where, indeed, the *miſy*, called the uppermoſt zone, or layer *(zona ſuprema)* of the *atramentum metallicum*, was always wanting, but ſoon appeared again, upon expoſure, for a little time only, in ſome degree of warmth. And at Braunſdorff, a mile from Friberg, I have taken up a black ſhivery rock, in which I have obſerved both *chalcitis*, called the middle zone *(zona media)* and *ſory*, called the under zone *(zona infima)*; nay, after repeated elixations, being kept for a few weeks under cover, it was again found over-caſt with white and yellow, but with this difference, that it proved a good, or, generally, a pure *iron-vitriol*, as was that from the Rothe-grube abovementioned, in the open air, not ſo much yellow, as white; but if mixt, as was that of Braunſdorff, and in particular aluminous, the yellow ſoon ſhews itſelf in the ſame air as that in which I lay the piece from the Rothe-grube: but in a warm room, eſpecially if placed near the fire, *vitriols*, whether of one ſort or another, pure or mixt, do, at laſt, all of them turn yellow; nevertheleſs I have not been able to obſerve any orpiment, conſequently nothing arſenical in what ſo eaſily, even in the cool air, as that of a cellar or vault, turns to *miſy*, though I have carefully examined it, as many others, and I myſelf at firſt might imagine; eſpecially as the Braunſdorff *pyrites-work* readily does, and is really very arſenical, of which hereafter, in particular, when I come to examine the queſtion, whether arſenic contributes to the *vitriol*-maſs, as ſuch.

The

The *atramenta*, atrament-ſtone, or atrament-ore, in a lax ſenſe, denote all ſorts of *pyrites*, ſo far as they yield *atrament*, or *vitriol*, for making ink, or a black colour; but in particular, a certain mineral, or ſtone, in which *vitriol* formally lodges, only intermixed with earth or ſtone. M. Linck has furniſhed me with two ſamples of it, the one from the Rammelſberg, the other from M. Baier, profeſſor at Altorff, which indeed differs a little in colour from the former, though it may be allied to it. Both of them not only yield a *vitriol* directly in water, but alſo entirely crumble to a brown-red earth; yet whereas the laſt ſort tinges iron of a copper-red, but the firſt does not exhibit the ſame appearance; and whereas the former manifeſts ſome alum, the latter, none at all; and whereas they are properly not a ſtone, but a concrete, rather of *vitriolic* earth, as appears from their falling to pieces in water, it will be no ways improper to ſuppoſe them a hardened earth, and either formed from *weathered pyrites* entirely, or, from the *vitriolic* waters, derived from *pyrites*.

Vitriol may be claſſed (1.) with reſpect to its internal eſſence or nature (2.) its colour and form, (3.) its origin, (4.) its uſe.

(1.) As to its eſſence, or nature, it always has for its baſis a metallic earth, and that either an iron, a copper, or both together; of theſe, either ſeparately or combined, with the conjunction of the ſulphureous acid, vitriol conſiſts: if of iron, it is called an *iron-vitriol*; if of copper, a *copper-vitriol*; but if of both together, it may properly be called a *mixt vitriol*. To this laſt may be referred the *white vitriol*, which, beſides its portion

of

of iron and copper, ſeems, though I cannot poſitively ſay it does, to partake of ſomething aluminous. We have few inſtances in the grooves of a pure, ſimple, either martial or venereal, *vitriol*; and when we would have it pure, the moſt careful methods of refining, evaporation, and cryſtalliſation, muſt be employed; or, which is the ſureſt method, the *vitriol* is to be prepared originally from its metal, either iron or copper: and that, both from the nature of the *pyrites*; not only in themſelves, or as *vitriol matrices* in their mixtion (as being ſeldom pure irony, though the iron generally predominates, nay, is often the only metal in them, and a *copper-pyrites*, even that ſort, on account of its rich copper-yield, called a copper-ore, is never without iron) but alſo from the nature of its encompaſſing rock and ſtone; in particular, the black, fatty, and ſhivery ſort, as matrices of the *pyrites*, wherein there is generally, at the ſame time, alum generated: whence alſo the famous Heſſian iron-earth is not always naturally pure in iron-*vitriol*, but often yields actual alum, which muſt carefully be parted from the *vitriol*.

(2.) Though this firſt claſſing of *vitriols*, with reſpect to their eſſence, might ſeem ſufficient, yet it may not be amiſs to take ſome notice of their colours, ſeeing theſe firſt ſtrike the eye: theſe, excluſive of the white *vitriol*, may be reduced to a green, or a blue, the green martial, the blue venereal; the former is very pale, like a pale emerald, commonly called a graſs, or ſea-green, and ought not to be confounded with verdegreaſe, the colour of which is a much higher green, ſomewhat inclining to a bluiſh caſt, eſpecially when prepared by art from copper and a vegetable acid. The blue reſembles a beautiful ſapphire and a laſul-ſtone, as this

this laſt has, doubtleſs, its origin from it, as we muſt neceſſarily conclude from certain characters and ſigns it affords. Now as iron and copper, as is before obſerved, may chance to be united together in a *vitriol*, it may be eaſily ſuppoſed, the colour peculiar to each metal, as green to the iron, or blue to the copper, may be in one caſe exalted, and in the other lowered; and one become a greener *vitriol*, the other a paler, one combined with ſomething coppery, the other with ſomewhat of an iron-earth. The white *vitriol* particularly deſerves mentioning on this occaſion, as it has its denomination abſolutely from the colour; yet, by no means, are we to imagine it a ſpecies entirely different from the blue and green in its ground-earth (as theſe are among themſelves) ſeeing it is always coppery, and its white colour is to be derived from ſomething incidental, if not from an aluminous earth, from the nature of its mixtion.

Vitriol might alſo be claſſed according to its different forms and figures, and the rather, as there are names to that purpoſe already extant; *trichites*, capillary *vitriol*, which often, like wool, hair, and threads, encompaſſes the mixt or ore-work; *Stalactites*, drop-*vitriol*, in form of icicles; *Cupæ roſa*, as uſually ſettling, in the courſe of ſhooting, on the edges of veſſels, like ſo many roſes and flowers.

The external, or rather, occaſional cauſe of the origin of *vitriol* affords a further diſtinction deſerving our regard. The internal formal cauſe of vitrioliſation ſhall be enquired into below, and is in all *vitriols* ſo far one and the ſame, as there is in each ſort a metal-earth for its ground or baſis, and the higheſt acid in nature, from what quarter ſoever

ever it come; nay, both the combination of these two parts, and their proportion, are the same in each: but so far they differ, as this acid salt is derived from different quarters, namely, sometimes from sulphur, which in *pyrites* lies next to the metal; sometimes from the air, being attracted by the desulphurated, nay, repeatedly elixated earth, as by a magnet; sometimes also, without sulphur, it is formed only by the medium of fire, as we experience in that extraordinary body, *calamy*; sometimes a prepared *vitriol*-oil itself comes to be incorporated, in the common manner of solution, with a formal iron.

From all these circumstances to select only the most general; *vitriol* is produced either spontaneously, or by art, and accordingly we have a twofold sort, a native, and a factitious. But, first, we are to avoid here the being misled by the term *waxing-troughs*, used in the *vitriol*-huts, in which troughs, as the workmen say, the *vitriol waxes*, or grows; since 'tis only a shooting, or crystallisation of a *vitriol* already *waxen* and generated, only still contained in a large quantity of water, which is to be boiled away. Many also imagine grown or native *vitriol*, which *breaks* vein-wise in firm entire rock, such as is the Hungarian sort, to have something extraordinary in it, compared with that usually formed into icicles, or flakes, in old mine-works, though both are originally derived from dissolved *pyrites*, and differing in nothing from that generated at the *day*.

The several appellations, *vitriolum coctile*, or *vulgare*, *concreticum*, *stalactites*, *stillatitium*, *cupærosa*, *trichites*, *leucojon*, or rather *lonchoton*, or *lanceatum neophyton*, *diphryges*, *magnesia vitriolata*, &c. do

do not denote a difference in the thing itſelf, but only a different method of production or preparation, or ſomething incidental, *&c.*

Vitriolum ſtillatitium, *ſtalactites*, *ſtalagmites*, or *drop-vitriol*, ſignify only the figure of this metallic ſalt, in icicles, jags, and flakes, ſuch as is to be found in mines, like a froze-water, or an ice; alſo ſuch as uſually ſettles in the pans, trunks, and veſſels of the *vitriol*-huts.

Vitriolum concreticum, or *condenſatum*, according to Dioſcorides and Galen, is that procured from *vitriolic* groove-waters, by a ſpontaneous evaporation in the open air. Caneparius, from Dioſcorides, alledges the concreted not to be ſo good as the *drop* ſort, but this may be meerly incidental, as one ſort may happen to be more ſaturated, and richer in colour; another, more watery, conſequently poorer; but even this laſt may be heightened in virtue by a more ſlow evaporation and ſhooting, as by this means ſalts come to acquire more of compactneſs and body.

Vitriolum coctile, or *vulgare*, boiled or common *vitriol*, is the ſort elixated with water from *vitriolic* ores, earths, and ſtones, particularly from *pyrites*, and procured from the lie by boiling and cryſtalliſation, as is the uſual way in the *vitriol-huts*. 'Tis called *vulgare*, as being what is commonly ſold, and at an eaſy rate; alſo, as it yields another boiled vitriol, which may be called *artificial*, or prepared by art, namely, from a metal, and a *vitriol-acid*, which muſt needs be right pure and fine, and, on account of its coſtlineſs, really uncommon; though in fact this diſtinction be immaterial, as all ſaleable *vitriol*, with us, is prepared by elixa-

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tion and boiling, conſequently by art, and a genuine *groove-drop-vitriol* is ſomewhat rare.

Neophyton, a virgin *vitriol*, which, and the *trichites*, are a grown or native ſort, either in the *groove*, or at the *day*, from *pyrites* opened by the air, without an actual fire.

Diphryges is a term of conſiderable ambiguity, yet not without a meaning; this, if not purely *vitriolic*, is yet either mixed therewith, or derived from the matter whence *vitriol* itſelf generally derives. From the etymon of the word, it ſhould denote ſomething *roaſted*, which makes it probable it ſignifies a burnt or calcined, not a crude mineral, or *pyrites*: or, the term may be derived from Phrygia, and ſo denote a *pyrites dephryges*, or a *pyrity*, *vitriolic* ore from Phrygia.

Leucon, whence *leucojon* is derived, ſhould, doubtleſs, denote a white *vitriol*. Mercati and Salmaſius hold the term to ariſe from a paſſage in Pliny miſunderſtood, where, with Dioſcorides, ſhould be read ΛΟΓΧΩΤΟΝ, *lanceatum*, and not *leucojon*, to denote a *vitriol* ſhot into needles or lances, conſequently of affinity with *trichites*.

There ſtill remains another claſs of *vitriols*, which though little or nothing relating to their eſſence, is yet adopted by many, eſpecially druggiſts, dyers, *&c.* as the Cyprian, Hungarian, Roman, Engliſh, Saltzburg, Admond, Geyer, Goſlar *vitriols*. But not to mention, that the veins of *vitriol-ore* may break ſhort, and change, and a new ſort of *vitriol* may perhaps be procured, unknown before in that particular place, the dealers in *vitriol* keep up theſe diſtinctions only from ſelfiſh views.

The

The nature of the climate ſeems not to contribute much to the mixtion of this metallic ſalt, ſo far as that the one ſort need be preferred to the other. The *vitriol-acid*, whether from ſulphur, or the air, proves every where one and the ſame, as all ſulphurs are fundamentally the ſame; the iron and copper, though, in regard to their admixture and working, they may differ according to the different places and times, yet equally lay themſelves open to the action of the acid, without communicating any the leaſt foreign admixture. Moreover, it may eaſily and often happen, that a country ſhall yield more than one ſort of *vitriol* at a time, and how ſhall theſe be diſtinguiſhed by the common name of the country?

Under the appellation Cyprus *vitriol*, there is now a-days ſold a blue venereal ſort, though, poſſibly, never from Cyprus. The Roman is properly martial, and ſomewhat venereal, but, by fining, becomes an *iron-vitriol*. As the times alter, ſo with them alſo change the methods of working in a country; nature either refuſing to afford any more materials for the purpoſe, or art finding it more profitable to employ theſe for other ends; for inſtance, inſtead of an *iron-vitriol*, to make a *copper-vitriol*, and *vice verſa*, or both at once. The Hungarian foſſile, or *atlas-vitriol*, is the only ſort, which here, for a certainty, in ſome circumſtances, diſplays ſomething peculiar, as that among the native ſort, it may hitherto be eminently called Hungarian; I ſay, *in ſome circumſtances*, not indeed in regard to its mixtion, in which it is not ſingular, but in regard to its origin and *finding*, as *breaking* uſually in firm entire rock, whereas other *groove-vitriols* are found in *ſhafts*, in the ſides and roofs of

levels and *drifts* only, and therefore lying open; I have alſo ſaid, *hitherto*, as the like ſort may, ſome time or other, happen to be found in other parts, when the former will, in courſe, have its abſolute name limited.

Thus long have I detained my reader with a relation of ſuch circumſtances as regard *vitriol* only externally, and yet I muſt add ſomething more, before I proceed to the principal part of this ſmall eſſay, in order to obviate any doubt and miſconception that might ſtill remain; namely, that the term *vitriol* is alſo employed for other metallic ſalts, beſides thoſe of iron and copper, ſilver, lead, and quickſilver, alſo tin and gold; yet the two latter bear ſomewhat more difficultly the being reduced to ſalts, which may be, and by many are called, *vitriols*; as *vitriolum lunæ*, *ſaturni*, &c. But as ſuch *vitriols* are prepared only by means of the ſalts from nitre, common ſalt and vinegar, which muſt be greatly inferior to thoſe in *vitriol* and ſulphur; therefore, not by means of the higheſt ſalt in nature, or what has reſerved to itſelf the iron and the copper for ſolution.

Tho' the *vitriol-acid* may ſeem to enter into ſome bodies, particularly quickſilver and lead, eſpecially after as due a degree of appropriation as poſſible, yet not in ſuch meaſure or proportion, as it is lodged in an iron and copper *vitriol*, which employ a very large quantity of acid; but in a quickſilver or lead calx, thus diſſolved, or rather only ſomewhat corroded, ſcarce any at all is required, nor is it neceſſary they ſhould be in ſuch a degree of union, as in a tranſparent *vitriolic* body, which may be ſuppoſed to be more cloſe and tender than ſuch a calca-

calcarious earth, as vitriol-oil reduces the white metals to, and wherein not ſo much as a ſaline or *vitriol* form can be exhibited; nor in ſuch a colour, as that in a quite ſurpriſing manner appearing in the unparallelled green and blue *vitriols*, never producible from other metals by their appropriated ſalts, except from biſmuth-ore; where, under peculiar encheireſes, or treatments, not only a genuine *vitriol-green* appeared, as M. Linck and I myſelf found, but alſo from my own ſmall experience, a genuine purple and blood-red: nor has hitherto at leaſt, what Caneparius, after the ancients, relates, been ſufficiently verified; namely, *that each metal does in ſolution ſhew its own peculiar colour*; eſpecially if we are willing to aſcribe the blue to the ſilver, and can prove this from a blue ſilver ſolution; though it be certain, this blue colour ever proceeds from ſome ſmall ſhare of copper in the ſilver; it never appearing, if we only run this ſilver ore over again to its metallic body, and refine it with nitre in the crucible, eſpecially in the caſe of a coppery lead, and a cold fulmination in the act of cupellation.

I know not, whether to call it an unguarded, or rather an undiſtinct way of expreſſing himſelf, when he pretends, an *iron-vitriol* is diſtinguiſhable by a brown-red; a *copper-vitriol*, by a green; as here he muſt certainly mean, not the *vitriols* themſelves, but the *vitriol-waters*; and then indeed an *iron-vitriol-lie* appears of a brown-red; and yet when pure, it is at firſt of a beautiful green; and a *copper-vitriol-lie* ſeems, but yet is not, really green. But, as iron and copper appropriate to themſelves the ſulphur-acid, to the excluſion of the other metals, ſo they not only quit theſe their native ſolvents, but alſo ſubmit to others; a very remarkable circumſtance, and deſerving our cloſeſt atten-

tion, is, that they not only diſſolve in the grand natural acid, but alſo in aqua-fortis, ſpirit of ſalt and vinegar, tho' indeed not with that intimacy of union as happens in the former caſe, ſeeing verdigreaſe, which is prepared from copper and wine-vinegar, or the like vegetable acid, and a *vitriol*, which may be made from it with ſpirit of ſalt, are by far not to be compared to a *copper-vitriol* prepared with ſulphur. In ſhort, under the appellation *vitriol*, when without any adjunct, ſpecifying its metal, we are never to underſtand any other than a ſort prepared either from iron or copper, or both together.

3. Of the production of *vitriol* from the *pyrites*. This is the laſt and moſt important head of enquiry; though indeed, it is not ſo perplexing as the external deſcriptions from the names, figures, and kinds of the *vitriol* were, ſeeing truth is conciſe and intelligible, and writers having touched but ſparingly on this head, it is leſs confounded by ambiguities and contradictions. We ſhall for the preſent drop the white *pyrites*, becauſe it is never known to yield any *vitriol*; and confine our remarks only to the yellowiſh and yellow ſort; which, together with their proper metal-earth alſo, poſſeſs ſulphur, by means of the acid ſalt, of which, the *vitriol*, as a new production, ariſes from ſuch earth. In the important buſineſs of *vitrioliſation*, we are particularly to attend to the inſtruments or means; and as theſe are two-fold, we have a two-fold *vitrioliſation*, or reſolution of *pyrites* to conſider. The inſtruments are air and fire; ſometimes the one, namely, the firſt alone; ſometimes, and that oftneſt, both together; at leaſt the ſecond is not generally ſucceſsful without the firſt.

(1.) As to the air, it produces its effects both in the groove and at the day; *pyrites vitrioliſing* not only

only in veins laid bare, but alſo in firm, cloſe vein-ſtone; if only the ſmalleſt fiſſure happen to give entrance to this penetrating, inſinuating body; and laſtly, in mineral and *pyrites heap-work*, which is either ſhot in trunks, or otherwiſe remains lying in the groove. The firſt may be manifeſtly obſerved from a view of ſuch veins laid bare; the ſecond, not only from *vitriolic groove*-waters and *cement-waters*, as they are called, which, according to all circumſtances, muſt have their *vitriol*, not from the contiguous, but from diſtant and cloſe vein-ſtones: alſo from many day-ſprings, ſuch as ſeveral medicinal ſprings are, which, in places where mines were never worked, carry *vitriol* along with them out of the earth: the laſt we experience very often; as I have had plenty of ſuch *pyrites* from the Rothe-grube, which I have examined on account of their ſpontaneous *vitrioliſation*.

At the day, or without the groove, they, in various places, become *vitriolic*, yet in ſome more than in other places; for inſtance, on that heap, or heap-work of minerals and earth, ſhot together near the groove, and ſeldom without *pyrites*; in vaults, cellars, and the like moiſt places; in rooms and cabinets; nay, on floors under roof or cover, according to the nature of the ſeaſon, the weather, and the ſituation of the building. But as the action of the air is here too ſlow to anſwer our occaſions for *vitriol* ſpeedily enough, the fire is to be called in aid; at leaſt, for the ſake of ſaving time, and on account of many *pyrites*, eſpecially the *copper-pyritæ*, which very ſlowly yield their contents without its aſſiſtance; but the ſulphur, in this way of *vitrioliſation*, is entirely loſt. Now, the fire is here applied in three ſeveral ways; either in cloſe veſſels and furnaces, wherein the *pyrites* is laid for procuring at the ſame

time the ſulphur, as is the way at the ſulphur-huts; or, out of a wind-furnace, whoſe flame plays on the *pyrites* lodged in an adjoining roaſting furnace: or on a roaſting-bed, where the *pyrites* may be beſt thoroughly burnt, or calcined: the firſt method is that uſed at Friberg, for the ſake of preſerving the ſulphur.

2. The fire is the next inſtrument; which, if not entirely ſufficient of itſelf, yet is ſerviceable for the firſt opening and preparing the *pyrites*, nay, indiſpenſibly neceſſary for many ſorts of *pyrites*, which would not otherwiſe ſhoot in the air. It is indeed of itſelf alone ſufficient, nay abſolutely needful, for exhibiting *vitriol* from other *vitrioleſcent* bodies, particularly foſſil calamy, from which, without burning, there is no hope of ſucceſs; and tho' the burnt calamy be never ſo long expoſed to the air, yet it would not, for all that, receive the more *vitriol*; which is ſomething equally peculiar; as is alſo in this very proceſs and act of burning, the ſulphur-production. The burnt, or calcined *pyrites* do alſo, after burning or roaſting, without a previous expoſure to the air, yield, by the uſual way of elixation, a *vitriol*; but not generally (the reaſon of which difference I have not yet ſufficiently diſcovered) nor ſo richly, as when the air has previouſly for ſome time thoroughly worked them: but this and a great deal more muſt be attentively conſidered.

As (1.) In what the buſineſs of *vitrioliſation* conſiſts. (2.) What is procured from it.

As to the *vitrioliſation* itſelf, it depends on various circumſtances, particularly the following. The air is the principal agent here, and contains

two

two principles. (1.) An univerſal moiſture, or a rarified water. (2.) A ſalt fit to incorporate into many bodies, not always in the ſame manner, but diverſified according to the nature of the ſubject: whence bodies, eſpecially the dry, become not only moiſt, but alſo more ponderous: ſome, particularly the lixivious ſalts, entirely liquate, as the *olea per deliquium* manifeſt; ſome, and even theſe, moreover, receive another ſalt, as the bitter *vitriolated* ſalts, ſeparating from liquated pot-aſh, ſufficiently teſtify. Now, tho' the ſalt of the air, conſidered in itſelf, without at preſent regarding its ſaline nature in this or that particular place, be various; or, tho' it may differ according to the difference of the ſubject, to which it gives or communicates itſelf, yet this is a thing that cannot ſufficiently be explained. However, from the juſt mentioned *vitriolated* lixivious ſalt, ſo much appears certain, that the *vitriol-acid* in ſuch ſalts, which differs in nothing from that in *vitriol* itſelf, may exiſt, if not formally, yet potentially in the air, and be found actually and formally, as ſuch, in theſe ſalts; as may inconteſtably be ſhewn from the genuine mineral ſulphur to be thence exhibited: and thus we have in the air not only what appertains to the exhibition of a ſalt as ſuch, and to its cryſtalline tranſparency, namely the water, as appears from the *vitriol*, efflorescent, or ſtriking out on *pyrites* in bare air, without addition of any actual water; but alſo, what moſt properly belongs to the eſſence of *vitriol*, namely the *vitriol-acid*; though it be only as an *ingredient* and *immanent* inſtrument in deſulphurated *pyrites*; but in the crude freſh *pyrites*, where the acid lies ſtill plentifully in the ſulphur, it acts as a penetrating inſtrument.

This collective air lays hold on and attacks the *pyrites*, and without it we are never to expect any *vitriol*, not even the ſpontaneous *vitrioleſcence* of *pyrites*. For, tho' I have had no opportunity of making any experiments with the air-pump, yet I have obſerved, that *pyrites*, when kept in a very cloſe glaſs, eſpecially in a dry and rare air, *vitrioliſes* with more difficulty than without the glaſs: and from this gradual difference it ſeems, that were it poſſible entirely to exclude the air, a *pyrites* would with the more difficulty, or not at all, become *vitriolic*. In ſhort, the air is entirely neceſſary for the purpoſe, and that according to all and every property thereof, not in its ſeparate but collective nature. For that the water alone is inſufficient, appears from the *pyrites* not giving in the leaſt, tho' lying, nay boiled in water never ſo long; as little effect has the *vitriol-acid* alone, ſeeing the *pyrites* remains whole, entire, and unchanged in the ſtrongeſt *vitriol-acid*; nor are both theſe together ſufficient; the affair depending not ſo much on the matter of the air, as on its motion, its ſoft and gentle attack, its wavy ambiency and inſinuating impreſſion, in order to the accompliſhing theſe deſtructions, and procuring new productions.

It has been already mentioned of white *pyrites*, that it yields no *vitriol*, tho' its arſenic, of which it principally conſiſts, yield in ſome meaſure to the air, as I have mentioned above of the *fly-ſtone*: it is the yellowiſh, or univerſal *ſulphur-pyrites* and the *copper-pyrites*, or the yellow copper-ore, that are properly ſubject to the action of the air; tho' for their improvement and exaltation, yielding ſlowly, and with ſome degree of reſiſtance; and with this remark-

remarkable difference, that the yellow give not at all, or with difficulty, at the day, but, in the groove very readily: for, having in various manners endeavoured to *vitriolise* the *copper-pyrites*; or the yellow copper-ore, and for that end expoſed it in numerous ways, and in different places, both whole, and beat ſmall, alſo in pretty large *heap-work*, both naked and covered, I could never procure any *vitriol*, though after an expoſure of many years; nevertheleſs, I would not pronounce the thing impoſſible, though very difficult: and therefore I would thus diſtinguiſh the ſpontaneous *vitrioliſation* of *pyrites*, and affirm the yellowiſh to be ſubject thereto, both above and under the earth; the yellow only under, and with the greateſt difficulty, above the earth. The reaſon of this different efficacy of the air depends doubtleſs on incidental circumſtances, into which we are unable, with all our art, to bring the yellow *pyrites*.

Now, it is a difficult matter to aſſign either a general or particular reaſon, why for each ſort of *pyritee*, the *vitrioliſation* happens either ſlow or quick, or not at all: for, though the copper greatly ſtands in the way of *vitrioliſation*, yet there are circumſtances and examples, wherein this does not always hold good; as I have had yellowiſh *pyrites* that contained no copper, and yet ſhooting with great difficulty, nay often not at all, into *vitriol*; of which we have many inſtances here at Friberg under the appellation *cobald*, or a ſulphureous, arſenical *pyrites*. There are two ſorts of *pyrites*, the one from Pretzchendorff, the other from the Ehrne-Schlange; the latter of which *vitrioliſes*, but the former not in the leaſt, and yet they entirely agree in their ſmall copper-yield. But what is moſt remarkable, there are *pyrites*, not only agreeing entirely

tirely in yield, namely, having neither copper nor arſenic, no not in the leaſt quantity, but only ſulphur and iron along with the unmetallic earth; alſo one and the ſame figure, colour, &c. yet one ſort; *viz.* that of Almerode in Heſſe, as alſo the ſort from Altſattel by Egra run exceeding quick to this metallic ſalt; another ſort, as that from Boll and Toplitz, very difficultly, nay, if not beat very ſmall, and buried in the earth, not at all. Amidſt thoſe contradictory inſtances, I have ſometimes dropped the copper, and aſſigned as cauſes, the figure, the colour, and ſometimes the texture and the grain of the *pyrites*, ſometimes again the arſenic, at other times the unmetallic earth, ſometimes the bed, and the adjoining or interſperſed minerals, and ſometimes one of theſe circumſtances only, ſometimes two or three at a time; or rather, as colours and figures are not cauſes ſo much as ſigns only of theſe cauſes; from the ſigns I have endeavoured to come at the things themſelves, and from their difference, was obliged to abide by the contents, the mixtion and texture of the *pyrites*.

From the arſenic there accrued a great degree of probability, that as the white *pyrites* does not at all *vitrioliſe*, its arſenic, according to its greater or leſs quantity, muſt at leaſt be the reaſon, why the yellowiſh often undergo *vitrioliſation*, and the yellow always with difficulty, or not at all; did not that ſort, which is without any arſenic, and yet remaining *unvitrioliſed* as the other, ſtand in the way: The unmetallic earth, which is two-fold, either flinty or calcarious, afforded no light in the caſe. From the texture, one *pyrites* appears not only denſer and more fine-grained than another, but has alſo, though no other *mixtion-materials*, yet another *mixtion-guiſe*, as well in proportion as in elaboration

boration and coction; conſequently, the air may work on one ſort ſooner and eaſier than on another.

Now, tho' the proportion and manner of connection of the particles of *pyrites* may cauſe a difference, yet we cannot ſufficiently judge of it from their apparent denſity and rarity; as I meet with *pyrites*, which, beſides their ſimilar nature, appear entirely of an equal grain and coheſion, though not equally ſubject to *vitrioliſation*. From the colour it holds, the yellower the *pyrites*, the leſs, though not the converſe; and the paler, the more ready it is to give or *vitrioliſe*.

From the figures, both the external and internal, as the angular, the round, the radiated, the teſtaceous, *&c.* there appeared ſome faint glimmerings of truth. Thus it holds, that the round *pyrites vitrioliſe* with more eaſe than the angular; and the radiated, than the teſtaceous. The reaſons I alſo find in the copper and arſenic, of which, both the round and radiated are uſually free.

In a word, I at length diſcovered the cauſes that now render eaſy, then difficult, or quite impede, the buſineſs of *vitrioliſation* to be various; one cauſe taking place in one inſtance; another, in another, and often two together, often one only, and often neither of the two: now, theſe are copper, arſenic, and the texture, and what ariſes thence, the denſity; not to mention the unmetallic earth, concerning the difference of which we may entertain ſome ſuſpicion, nor the different mixtional proportion.

Copper, certainly, is the greateſt obſtacle of all to this *vitriolic* reſolution, when even in the ſmalleſt quantity;

quantity; and the higher the *pyrites* riſes in this metal, the leſs it *vitrioliſes*; this is owing to the ſulphur, which being here ſet free from the metal-earth, and yet again operating thereon in another manner, is held very faſt by the copper, to which it adheres more cloſely than to iron: then the arſenic oppoſes together with the copper, not only in the *copper-pyrites*, but alſo in the *iron-pyrites* without any copper; inſtances of the one ſort are evident in every copper-pyrites-ore, of the other ſort in the Halſebrucke arſenical *iron-pyrites*.

Laſtly, the buſineſs alſo ſometimes depends purely on the texture, cloſeneſs, and grain, without any copper and arſenic, though this is the rareſt caſe, as I learn from ſome periwinkle and muſcle *pyrites*, conſiſting purely of iron and ſulphur, yet without ever running to *vitriol*. Often two cauſes concur, as is ever the caſe in the yellow *pyrites*, where along with the copper, there certainly lodges arſenic: often, the buſineſs turns on one cauſe only, namely, the arſenic alone, or alſo purely on the texture alone: often, all the three concur, namely, in the fine-grained and fineſt ſort of copper-ores: and, to conclude, we have here a confirmation of the axiom, that *one and the ſame effect may have very different cauſes.*

This difference, both in the mixtion and texture of the *pyrites*, manifeſts itſelf often in one and the ſame vein; where we have copper-ore and *iron-pyrites* lying in each other interſperſedly; and again, *pyrites* lying like ſo many nuts or eggs in a ſhell, wherein upon breaking it ſome ſmall veins and eyes of *copper-pyrites* appear. Among the Almerode *pyrites-balls*, commonly called iron-earth, and for pure ſulphur and iron the propereſt and beſt

ſort,

ſort, are found not only radiated and ſtellate balls, which are at leaſt of a different texture from the globular, but alſo conical; which, in regard to their metal earth, differ remarkably from both the former, and are not without ſome copper; though the ground and bottom, where they lie intermixed, nay compreſſed together, be one and the ſame.

In the territory of Boll, are whole tracts ſtrewed with various ſorts of *pyrites*, as the periwinkle, muſcle, nut, globe, and *radii* kind; and ſuch *pyrites* generally agree in mixtion, like that ſort in, and under the under-turf earth, and of like figures, and neither coppery nor arſenical; and yet I have had inſtances, though rarely, of *pyrites*, containing ſome little arſenic and copper, and yet produced in one neſt and matrix, near and among the former; a thing not to be wondered at, as ſuch mineral productions are ſubject to many incidents, which interupt their growth; nor is it at all ſurpriſing to find *pyrites* ſimilarly, and diſſimilarly *vitrioliſe*. The globular reſolve ſooneſt and with the greateſt eaſe; the radiated or conical more difficultly, and tho' they ſhould ſoon enough reſolve into *radii* or cones, yet they here remarkably ſtop ſhort, before they fully change to *vitriol*. The conical conſiſting of a number of cones or pyramids put together, with their points concurring in the middle, and their baſes again projecting into ſhort, either ſharp or obtuſe, and theſe again partly in broken angles; and where joined together, they are, doubtleſs, not ſo cloſe and firm, as in the remaining parts.

That the air is the genuine and abſolutely neceſſary inſtrument in *vitrioliſation* we have already ſhewn, and it may be ſummarily confirmed from this conſideration, that *pyrites*, which remain unreſolved

reſolved in the bowels of the earth, do at the day, or above the earth, remarkably change or vitrioliſe; and that without any thing foreign, beſides the acceſs of the air, from which, under the earth, they are at leaſt more ſcreened. Now, here it is worth remarking, that in many ſorts of *pyrites*, the *punctum ſaliens* of this new production acts from within the *pyrites* outwards, the *vitriol* not ſettling from without, but ſtriking out from within; as ſufficiently appears, not only from *pyrites-globes*, which, in their falling to pieces, generally from their middle emit genuine native vitriol, but from other angular pieces of *pyrites*, broke off from veins, and which on the ſide, where they are thus broke off, ever turn *vitriolic*.

Two queſtions with reſpect to the *pyrites-globes* here offer themſelves to our conſideration, (1.) How the air can break into ſuch cloſe compact bodies.

(2.) Why it does not rather eat into their circumference, and thus operate from without inwards. As to the firſt, the round *pyrites* in general, or ſuch as *vitrioliſe* in that manner, are internally, and in their inmoſt parts, not ſo cloſe and compact as in their external circumference; nay, have a ſmall, an almoſt unobſervable cavity; further, that this ſort, as was obſerved above, conſiſts of a number of cones or pyramids, and not only upon a ſpontaneous reſolution, but upon the application of an external force, whilſt ſtill freſh, falls to pieces of ſuch a conical form. Now, as it is at theſe *radii* or cones, iſſuing out from the centre, we ever obſerve the reſolution of theſe cones to happen, they are, doubtleſs, traces of ſmall tender fiſſures, or ſigns of the coheſion not having hitherto become ſo cloſe, as theſe cones do not ſo readily

readily fall to pieces croſs-wiſe, as in the direction of the radii; and in theſe fiſſures, the air inſinuates itſelf to the heart of the pyrites-globe.

This alſo may ſerve to account for the reſolution of the ſecond queſtion: it is true, the air firſt acts, or rather falls upon the *pyrites* externally, but it acts moſt powerfully, when in a proper place, and at undiſturbed reſt; both which it finds in the centre of a round *pyrites*, which is in and about the centre, if not quite hollow, yet of a porous texture: whence the cloſer a *pyrites-body* is, with more difficulty does the air not only force into it, but the leſs of it can be collected therein. And hence a piece of *pyrites*, which is now no longer a whole, nor thus to *vitrioliſe* from within outwards, but to be corroded externally by the air, does in the open air and laid naked there, vitrioliſe with difficulty, or not ſo quickly, as when laid in a heap, and thus lying at reſt, and in ſome meaſure warm: and thus the innermoſt receſſes of ſuch *pyrites* become impregnated with *vitriol*; which burſts out by breaking aſunder its ſhell. Nevertheleſs, when ſuch round *pyrites*, as ſtill lie in the earth, muſt *vitrioliſe*, they fall not aſunder in ſuch pieces, but remain entire, notwithſtanding which they part with their *vitriol*, either by an evaporation, exſiccation, and a reduction to an earth, by an unobſerved elixation, though I ſuſpect the former rather than the others; thus they exhibit themſelves internally neither *pyrity* nor *vitriolic*, but like a brown, yellowiſh, ruſty iron-ſtone, or an iron-earth firmly baked together; as in particular may be ſeen from periwinkles, and muſcles, exhauſted of their *pyrity* ſubſtance; which in their ſhells, ſtill really exiſting, though generally calcined,

cined, are often, without falling to pieces, entirely ſhattered and burſt as by a force, evidently acting from within outwards; and this may be judged to be owing to the *vitrioliſation*.

The reaſons certainly are, the air's neither ſo briſkly entering into, nor ſo powerfully acting upon them; in regard they lie, if not in a peculiar and firm narrow caſe or encloſure, as a ſtone, which yet is not uncommon, yet covered under the earth, and in ſome meaſure only, not entirely, expoſed to the acceſs of the air: again, tho' their ſhells may crack, yet their parts ſeparate not to any diſtance, as being urged or preſſed upon by the adjoining earth and ſtone; and though by the act of *vitrioliſation*, they may turn to an earth, yet they muſt hold together, become compact, nay even petrify.

Such periwinkles and muſcles ſtuffed with *pyrites*, or pieces of *pyrites*, of the form of periwinkles and muſcles, are found cracked, ruſted, and again hardened, at Boll, and the adjoining territory, in great quantities, and in various ſorts; particularly, *chamæ*, *pectunculi*, *cornua ammonis*, &c. but never, ſo far as my experience has reached, in *lapis lyncis*; the cavity of which is nevertheleſs often found filled with *pyrites*, a circumſtance deſerving peculiar notice; and I have diſcovered at the Schloſsberg at Toplitz a *terebratula*, entirely ruſted and remaining firm; a thing I never obſerved before, whatever pains I took in the ſearch.

Further, I beſides remarked, that many ſuch ſea-ſhells, exhauſted of their *pyrites*, were only externally ruſted over; but upon preparing them both in their entire ſtate and beat ſmall, for *vitrioliſation*,

liſation, though in vain, I found them of ſuch cloſe texture, as to render them unfit for it, either externally or internally.

Laſtly, I have had inſtances, where the bodies were thoroughly ruſted, yet neither burſt, nor fallen to pieces; but then many ſuch ſhells are not pure *pyrites*, but greatly mixed with other earth, and alſo ſtone, particularly, ſhivery, loamy, and ſpathy matters; nay, ſome contain no *pyrites*, but ſuch earths only; and, in that caſe, neither an expanſive force, nor a *vitrioliſation*, but only a leiſurely ruſting, and reduction to earth, are to be expected.

Thus much of freſh *pyrites*; but that the air alſo works on the deſulphurated and thoroughly burnt *pyrites* towards *vitrioliſation*, we ſhall hereafter mention, having firſt to treat of the other inſtrument, namely, fire. And here we muſt premiſe ſomething on the internal cauſality, or how the ſpontaneous *vitrioliſation* of *pyrites* happens internally.

Philoſophers might readily call it *magnetiſm*, to denote a mutual action of damps and juices; on the ſide of the patient, namely, the *pyrites*, conſiſting in a *receptivity*, and on the ſide of the agent, or air, in an *influx*. Miners expreſs it by the term *weathering*, and very properly, as they uſually call air, *weather*; beſides, affirming, that we are by it to underſtand, not a deſtruction of the matters of the *pyrites*, but only of its texture or coheſion; leaſt of all are we to imagine it a reduction to its original parts, or a ſeparation, but a new production. The reſolution here produced is indeed ſo far a ſeparation into parts, as the ſulphur is abſolutely to be ſet free from its metal earth, but in that very act the

new production happens; and as ſoon as the ſulphur is thus ſet free, ſo ſoon does it lay hold, with its acid or ſalt, on the looſened metal-earth, and therewith exhibit the *vitriol*.

Hence, in the proceſs of *vitrioliſation*, though never ſo attentively performed, not the leaſt ſeparated ſulphur is to be found. Now as little as in this reſolution of the *pyrites*, or deſtruction of its texture, the buſineſs is a ſeparation, though this laſt, in ſome meaſure, happeneth; ſo little is the exhibition of the *vitriol* a ſeparation from *pyrites*, as really, and in truth, to be conſidered a new production: for, the parts of the *vitriol*, namely, the ſulphur-acid and metal-earth, are indeed in the *pyrites*, but not thus combined.

In brief, *vitriol* is as little in the *pyrites*, as brandy and a volatile ſalt are in the grape and freſh urine; but are all three produced from *pyrites*, muſt, and urine reſpectively, by means of *weathering*, fermentation, and corruption; and that not only by a transformation of the particles of the *pyrites*, muſt, and urine, but alſo by an actual eſſential influx of the particles of the air, conſidered above in their water, earth, and ſalt, and which here not only paſs through, but adhere to the freſh *pyrites* and its particles, *i. e.* are not ſo much a *tranſient*, as an *immanent* inſtrument; as appears from the ſeveral productions and transformations in the three kingdoms.

It ſeems, however, probable, that air enters not ſo much by its ſaline part, as by its univerſal humidity, into freſh *pyrites*, for the exhibition of *vitriol*. The probability of this hypotheſis may be inferred from hence, that there already adheres to ſuch

ſuch *pyrites* much ſalt, eſpecially in the ſulphur, ſufficient to doſe its metal-earth: and it cannot be ſhewn, that the leaſt ſulphur flies off without producing its effect. We are not, however, to deny the ſalt in the air its incorporating virtue, as it ſtands inſeparably united with the humidity, tho' its humidity is here ſtill more neceſſary, for exhibiting a true ſaline form, ſuch as the *vitriolic* muſt have, ſeeing it is in no caſe procurable without water. And though in ſpontaneous *vitrioliſation* the humidity of the air always manifeſts itſelf, yet other water is not to be excluded.

For, firſt, the former is aided by the latter, as we ſee upon expoſing to rain, or ſprinkling with water, the *pyrites*, either beat ſmall, or in its groſs ſtate, and laid on large heaps together; *aided*, I ſay, and not the former replaced by the latter, as *pyrites*, when entirely plunged in water, and thus excluded the acceſs of the air, never turns to *vitriol*: ſo that notwithſtanding the ſprinkling with rain and water, the whole buſineſs muſt chiefly turn on the motion, warmth, power, and influx of the air; and then alſo, by means of other water, larger and purer cryſtals are procured, and in a larger quantity. But the moiſture of the air alone being employed, the cryſtals prove ſmall, like grains of ſand, nay, often like hairs; and thus, when the *pyrites* falls to pieces and to earth, there is no ſeparating them from the impurities, without either waſhing them with water, or without elixation and a new cryſtalliſation.

But poſſibly, from the nature of the grooves, the moiſture of the air is not the whole, but the waters, trickling down on all ſides, may waſh out the tender *vitriol-ſhoots*, and coming afterwards to

ſettle a little, or otherwiſe evaporate, let them fall again, either in icicles, from the roof and ſides of *levels*; whence we muſt make ſome diſtinction between *grown*, or native *vitriol*, as ſpontaneouſly produced from *pyrites*, namely, between that ſort formed barely by the humidity of the air, without any addition of either day or groove-water, and that other formed by the acceſſion of an actual water. The former we are not to expect in the grooves, and 'tis rare that it is *grown*, though ſhot on the ſpot where found: whence appears the great folly of alchemiſts, in that they would employ for their *great-work* that produced in the grooves by the water of the air alone, a thing quite impoſſible.

For the *vitrioliſation* of *pyrites*, there are, beſides the action of the air, other aiding or concurring circumſtances requiſite, at leaſt when it is to be rendered eaſier, or to be more ſpeedily diſpatched. Thoſe on the ſide of the *pyrites* itſelf, though indeed only negative, I have already mentioned, and now come to this, namely, that the *pyrites* muſt contain little or no arſenic or copper, nor be of too cloſe a texture: to which we may add this conjecture, that the black vein-ſtone, or rock, uſually called *kneiſs*, at Friberg, and almoſt ſhivery, but much blacker and harder than *ſhiver*, is, if not a co-operating cauſe, yet a ſign of an eaſier *vitrioliſation*; but as to external circumſtances, there are principally three, which facilitate this operation. Firſt, and principally, the *pyrites* is to be laid together in as large a heap as poſſible, and to lie expoſed to the weather and ſun, nay, in dry weather to be ſprinkled with water, as otherwiſe it cannot heat or work ſo well: or, in the ſmall way of proof, the beating ſmall the ore, the choice of a fit place, as a cellar, or the like warm ſituation, and the laying it in a powdery

powdery heap, are to be called in aid; and theſe failing, I know not further how to adviſe, when you would have a *vitriol* without fire, or the addition of any thing extraneous.

As to the other inſtrument in *vitrioliſation*, namely the fire, its relation thereto is ſomewhat different from that of the humidity of the air. Such *pyrites* as ſpontaneouſly yield not to the action of the air, or too difficultly and ſlowly, or that muſt previouſly be worked for ſulphur, are firſt, either roaſted, burnt, or deſulphurated, and this holds, in reſpect of the difficulty of *vitrioliſation*, not only of the yellow *pyrites*, or our copper-ore, but alſo often of the yellowiſh, that is, of many ſulphur or iron *pyritæ*. But here occurs a difficulty, namely, that the burnt *pyrites* muſt generally be thrown on heaps in the open air, though there is alſo a ſort, from which, immediately after burning, nay, tho' ſtill warm, a *vitriol* may be elixated. I made trial with all my *pyrites*, under the different circumſtances of being much and little burnt, put warm and cold into water, but often without procuring any *vitriol*.

From the inſtance of foſſile calamy, which, immediately upon burning, nay, whilſt ſtill warm, yielded not only a good deal of *vitriol*, but alſo not a little alum, I imagined the ſame would ſucceed equally well, if not better with the *pyrites*, as containing the ſulphur, conſequently the acid of the ſulphur not only ſo plentifully, but alſo the metal-earth immediately; whereas in calamy there is little formal ſulphur, conſequently, little ſulphur-acid; but it muſt firſt be, by means of the fire, both generated and rendered active. The *pyrites* mixt-work of Geyer, which is properly an iron-ſtone in-

terſperſed with *pyrites*, is a ſort, which directly upon burning (for it proves too poor for making ſulphur) has been elixated for *vitriol*, yet with me it has not yielded enough; though the reaſon of ſuch *pyrites* giving *vitriol* without air, barely by means of the fire, be, that the ſulphur therein finds a prepared corporal iron, wherein its acid ſalt may directly lodge, yet the caſe is certainly different in a pure, firm *pyrites*, the iron-earth of which is not thus prepared. I have, however, procured a little of ſuch *vitriol*, and the ſmall ſhare of *vitriol* from all ſorts of *pyrites*, ſhew the poſſibility of the thing.

But though I could not ſucceed in the manner I had been directed at the *vitriol-huts*, yet I find no reaſon to deny that *vitriol* may be procured from burnt *pyrites*, without a previous expoſure to the air, eſpecially when I conſider the peculiar experiment of the *vitriol* from calamy: beſides, that from the miſcarrying in the ſmall way of proof, we cannot queſtion the truth of the large way of working (as, in other reſpects, the concluſions from proofs in the ſmall to yields in the large way, are often very fallacious) as I have experienced how difficult in general it is to aſſay *pyrites* for *vitriol*, without employing large heaps for the purpoſe.

Yet it may be made appear probable, that the air contributes ſomething here, when we conſider the nature of fire, as yielding no flame without air, nay, deriving by and from it, together with the fatty, ſoot-particles, its needful fuel and *pabulum*; and thus the air is at leaſt an indiſpenſible inſtrument in *vitrioliſation*. But be this as it may, ſuch *pyrites* directly elixated upon burning, when, to be further worked for *vitriol*, is to be ſhot in the air,

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and there to lie for ſome time. Upon the whole, by means of the air, a freſh *pyrites vitrioliſes*, air plays in amidſt the burning of the *pyrites*, and, laſtly, exerts its efficacy in the heap, when the *pyrites*-earth is become unfit for further impregnation, and thrown on the *ſlag-heap*, under the name, *caput mortuum*.

Thus the fire is, in the buſineſs of *vitrioliſation*, to be alſo conſidered as an immanent inſtrument, ſo far as, in part, the air is not only inſeparably contained therein, but is almoſt the very ſubſtance of fire itſelf; alſo ſeeing the fatty, phlogiſtic particles from wood or coals cannot fail to be communicated (hence an open-roaſted reſolves better to *vitriol* than a cloſe deſulphurated *pyrites*) yet here, fire and air are not to be conſidered on an equal footing, but fire is alſo to be conſidered as a penetrating, opening inſtrument; particularly as what fits and prepares the *pyrites* for the action of the air. For, not only the ſort in general, which muſt undergo the torture of the fire, is to receive from the air the true matter of the *vitriol*, but alſo that which immediately upon burning reſigns its *vitriol*, is afterwards to be committed to the air, in order to a fuller yield.

Now, all ſorts of *pyrites*, whether ſpontaneouſly *vitrioliſing*, or prepared for *vitrioliſation* by the action of the fire, will take a long time, nay, a courſe of years, before nature has thereby worked them dead, or exhauſted them of their *vitriol*: but as in the *vitriol-huts* the waiting ſo long would not defray the charges, beſides, that the *vitriol* produced would be apt to be waſhed away by rain and water, or ſoak into the earth, and there be loſt, were we to wait till the *vitrioliſation* was fully finiſhed; it

is therefore uſual, within the year and day, to boil out the *vitriol*, according to the plenty of *heap-work*, and in proportion to the demand for the commodity. And ſhould any one, in order to promote the buſineſs of *vitrioliſation*, take it in his head, that ore, the more it is ſtamped ſmall and powdered, the more it would lie expoſed to the action of its menſtruum, from the axiom, that *the more ſides a body thus expoſes, the ſooner it will be reſolved*, he would find himſelf greatly miſtaken; as thus, the ore would lie more cloſe together, ſo as to exclude the action of the air. Yet it depends on practice and experience, to determine whether the often turning what was inſide outward, may be of any advantage or no.

It remains to ſay ſomething of the white *vitriol*, a matter greatly unknown, both in its origination and mixtion: it is white, and not barely ſo to the eye, as *vitriol* in general uſually appears, when in a capillary or woolly ſtate, and conſequently fine and tender, or when minutely rubbed, or dried and crumbled by air and heat; but eſſentially, and in its mixtion, white, as plainly appears from its cryſtals, be they ever ſo large and thick. It is true, we have alſo a bluiſh ſort, but this external blue caſt may, by a proper cryſtalliſation, be diſcharged. Though its origination be utterly unknown to us, yet I cannot omit mentioning what I myſelf have obſerved, *viz.* that the *pyrites* of Pretzſchendorff, which is a yellow cubical ſort, intermixed with ſomewhat of a mock-leady matter, and lodged in a black-grey ſhivery rock, has, after deſulphuration, and a long expoſure to the air, yielded an actual white *vitriol*, differing in nothing from the Rammelſberg ſort, ſo far as I hitherto find (after purging ſuch from its adhering copper-blue) either

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in colour, taſte, or habitude in the fire. And all we learn from the accounts from the Rammelſberg is, that the ores there are alſo *pyrity* and mock-leady.

In the Pretzſchendorff ſort, it is certain, that beſides the *pyrites*, there is alſo mock-lead, which holds ſome iron-earth, and a little ſooty fly-powder, or arſenic, conſequently no other contents than what are in *pyrites*, and therefore the buſineſs ſhould ſeem to turn on the unmetallic earth, which conſtitutes the greateſt part of mock-lead, beſides what the external rock may contribute; which though alſo to be met with in other *pyrites*, yielding no white *vitriol*, yet we are to remember, that new productions, as *vitriols* are, depend not ſo much on the great variety of matters to make up their mixtion, as on the different proportions of a few, the places of generation, *&c.*

From the former prejudice generally ariſes great difficulties in acquiring a competent knowledge of nature, in imagining, firſt, *mixts* to have taken their riſe from ſuch matters as they are found to conſiſt of; the abſurdity of which appears from the hiſtory of alum, which conſiſts indeed of a calcarious, or if you had rather, a chalky earth, and yet neither nature nor art can produce it from thence: again, in being accuſtomed, in the operations of nature, to the terms, *extraction*, *ſeparation*, *combination*, &c.

As to the mixtion or nature of the white *vitriol*, ſo far as my little obſervation reaches, it may be concluded, its ground-earth is, firſt, aluminous, then, coppery; the copperineſs not only appearing in the common white *vitriol*, as worked from the Rammelſberg ores, by plunging an iron into it, but

but alſo in the purified, and even the Pretzſchendorff ſort, which diſcover themſelves by the actual coppery taſte, and by its redneſs after calcination; this colour certainly indicating ſomething metalline, though, from the taſte, not an iron.

It might be ſomewhat difficult to explain why ſuch a white metal-ſalt ſhould not be procured at our *vitriol-houſes*, equally as at the Hartz, did not the buſineſs depend on the copperineſs of the *pyrites*, which is obſerved to be more diſtinguiſhable there than with us: and as to its unmetallic earth, we have reaſon enough to affirm, it is not of the ſame ſort with the ground-earth of bitter ſalts, and ariſes, if not from common ſalt, yet from calcarious, ſpathy ſtone, from which ſuch middle or *vitriolated* ſalts indeed may, but a white *vitriol*, though with the addition of a metallic earth, never can be prepared; moreover, we obſerve nothing ſpathy among our Pretzſchendorff veins: nay, ſuch a *vitriolated* ſalt may well contain ſomething metallic, as the *arcanum duplicatum*, which, in the burning or diſtilling for *aqua fortis*, ariſes from the alcaline ſalt-petre earth, and the *vitriolic acid*; yet ſo that its fundamental bitterneſs cannot be concealed, though entirely ſeparable from the metallic impurity; whereas, on the contrary, there is, in the white *vitriol*, neither bitterneſs to be obſerved, nor does the metallic taſte ceaſe to manifeſt itſelf.

Laſtly, we are to take notice, that white *vitriol* is never found in our grooves; though, according to Lohneiſs, in thoſe at the Rammelſberg, it is met with native in the form of icicles and roſes. Thus much we know, that it is procured in the way of a cryſtalliſation, not in large ſhoots indeed, but like

like a ſand only, while urged by a briſk boiling; though from theſe ſmaller cryſtals reducible to larger lumps.

On the head of the origination of white *vitriol*, I cannot omit mentioning a query put to me by an ingenious friend, namely, Whether *zink*, or rather, zinky ſubſtances, ſhould here be entirely diſregarded? This at leaſt is true, that this ſurpriſing body principally ſhews itſelf at the Rammelſberg, nay, is no ſtranger with us at Friberg, under another form indeed; though the greateſt artiſt will find it difficult enough to hit on a method of properly combining it in its ſeparated ſtate with the ſulphur-acid, into ſuch a white *vitrial*.

Under the head of *vitriol* from *pyrites*, we muſt obſerve the difference of elixations, namely, that many of them, having ſtood for ſome weeks, turn mouldy, as happened to myſelf once from the *mixt-work* of the Rothe-grube; and again, if I miſtake not, from the *terra martis Haſſiaca*. Now *pyrites*, as ſuch, exhibits no ſuch appearance, but the adjoining interſperſed minerals, and indeed the ſhivery, loamy, black fatty ſort may, though not all, yet a certain ſort of them; ſuch in general are thoſe that yield alum; and all of a fatty, bituminous, inflammable nature, or of a muddy origination: though I propoſe this only as a query, and not as a certain undoubted truth.

There is alſo incidentally, from the proceſs of *vitrioliſation*, alum procured; not from the *pyrites* in its proper mixtion, but from the bituminous matter adhering to the *pyrites*; when its acid chances to lay hold on the metal-earth, it may not, at the ſame time, leave untouched the black, fatty, adjoining

joining and interſperſed mineral, and thence exhibit alum. We purpoſely omit mentioning why ſuch vitriolic, aluminous *lies* now ſhoot firſt to alum, and that *per ſe*, without a precipitant, as happens in thoſe of Braunſdorff; again, why to *vitriol* firſt, and then to alum, not eaſily without a precipitant; and how alum, made *per ſe*, differs from that made with *addition*, as ſometimes of urine, then pot aſh, then quick-lime, and ſometimes of ſpirit of urine; and the rather, as we expect a particular diſſertation on the ſubject of alum from profeſſor Baier, at Altorff.

An earth here diſcovers itſelf, which is ſometimes grey, ſometimes yellow; the former called *ſlime*, the latter, *ochre:* the ſlime is procured not ſo much from *pyrites*, as from the earth intermixed and incorporated with it; though whether ſuch earth be ever procurable from the mixtion of the *pyrites* itſelf, a thing I could never find, deſerves examination; the ochre, on the contrary, appearing of a brown-yellowiſh, alſo of a ruſty caſt, and conſiſting partly of a metallic, ſometimes iron, ſometimes copper, and partly of an unmetallic earth, is more certainly derived from the *pyrites*, though not immediately, but mediately only, by means of the *vitriol*, to which the *pyrites* muſt be firſt reduced. It is found not only near and upon crumbled *mixt-work*, but waſhed away by the waters, in what is called the *gurs*, or metallic juices, and deſerves a peculiar regard; as does alſo that ſulphur-yellow earth, precipitated in boiling for *vitriol*, and burnt to a red colour, yet not to be confounded with the ochre, being not only brighter, but alſo ſomething more than a pure earth, namely, ſtill conſiderably *vitriolic* and aluminous.

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There ſtill remains to be conſidered a mellaginous liquor, deſerving the more notice, as it has been diſregarded, or, at leaſt, not expreſsly mentioned by any authors, except Geoffroy * and Stahl †. This liquor is ſuch, that (1.) though, by means of the gentleſt evaporation, ſome ſhoots may be ſeparated from it, yet they are not ſufficiently cryſtalline, and what remains will not ſhoot further, but only become a dried maſs. And (2.) which is the more immediate object of our preſent attention, that after drying, if again expoſed to the air, it becomes ſmeary, moiſt, and fluid. Again (3.) when dried ſpontaneouſly in a warm air, it ferments like lees, and thus its parts undergo a mutual action among themſelves. And here may be conſidered, what, and how many are thoſe juices, or thick liquors, which contain ſalts, without reſigning them, either to cryſtalliſation, or the other methods of ſeparation; but, for the preſent, I ſhall confine myſelf to the mineral kingdom.

We find arſenic, and what is allied to it, orpiment, *&c.* which, along with the acid of ſalt-petre-ſalt, turns to a very ſurpriſing viſcous matter: metals might generally be reduced to this form, could the proper medium for each be found out, as the abovementioned friend informs me from his own experience, of gold by means of urine. This buſineſs, however, ſucceeds with iron and copper eaſier than in any other metals, and in a peculiar manner; eſpecially as they are the two, that, along with the ſulphur-acid, aſſume the ſurpriſing beautiful form of *vitriol.*

Copper

* Mem. l'Acad. l'An. 1713. p. 225.
† Bedencken vom Sulphure, p. 285.

Copper furniſhes a remarkable experiment to this purpoſe, upon properly evaporating the green water remaining from a ſolution of ſilver precipitated by copper; but iron more clearly, as I have found after employing the greateſt degree of care, having more than once obſerved, that working it with oil of *vitriol* for *vitriol*, there ever remained ſomething oleaginous, that could not be made to ſhoot, and only became a dried maſs: and as I did not over, but rather under doſe the iron therewith, I at firſt began to ſuſpect the purity of my iron; and being well apprized that many ſorts of iron, particularly the caſt, though I never employed ſuch in this proceſs, nay, other common iron, may contain ſomething extraneous, as common ſulphur, which is no conſtituent part thereof, ſometimes lodges therein, I employed the beſt Steyermarck ſteel, as pure an iron as is poſſibly procurable, and yet even this ſort manifeſted the ſame thick oleaginous liquor that common iron did, and became dry in the fire, but ſmeary again in the air.

After the arſenical matters, and the metals, the *vitriolic*, and the like mixtures, are what are procured from *pyrites*, either with or without fire, alſo from calamy-ſtone, and the foſſile Hungarian *vitriol*; as thus, take *vitriolated pyrites*-mixt-work, as of Braunſdorff, and the Rothe-grube; alſo *vitriolated* Heſſian earth, burnt foſſile calamy, Hungarian *vitriol*, without picking out the green pieces; taking the white amongſt them as they come to hand, diſſolve each in water, filtrate, boil, and evaporate, and ſet to ſhoot ſeveral times again; then commit what remains, which will prove highly oleaginous, to the ſofteſt degree of a ſponta-

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neous evaporation, without applying any fire, and thus let it ſtand for ſome months, and there will ſomething ſeparate in that time, which proves not cryſtalline, but crumbly, like hemp-ſeeds and ſmall peaſe, and what remains after, proves ſtill thick and oleaginous, as before. Now nothing further happens, but that when the laſt is not removed with the ſame care, but the whole left long together to dry away in the mild warmth of a ſtove, this oleaginous maſs, when become of the thickneſs of butter, heaves and riſes like a dough, in its ſtate of fermentation.

As to what M. Geoffroy * has obſerved in this caſe, though he divides *vitriol* with more accuracy than M. Lemery, into blue, green, and white, yet he appears not to have had ſo juſt a notion of the white ſort, which he calls *couperoſe blanche* †, as he pretends it to be mixed either with ſome calamy (which it may, in regard to the earth it holds for the generation of alum, and poſſibly alſo for the baſis of the white *vitriol*) or to conſiſt of an irony earth, and ſome lead or tin, a prejudice he was probably led into from the white colour of the *vitriol*.

Now the oleaginous ſmeary matter remaining after the ſhooting of the *vitriol*, and which he calls the *mother-water*, he procured not only from freſh *vitriol*, but alſo from the ſort he dried to whiteneſs, and likewiſe from what he had treated in the fire to yellowneſs, for obtaining the volatile ſpirit of *vitriol*. He then obſerves, that from freſh *vitriol*, upon the firſt re-ſolution and cryſtalliſation, a grey muddy earth had ſettled to the bottom of the glaſs; a thing

* Hiſt. de l'Acad. l'An. 1707. p. 237.

† Ib. l'An. 1713, p. 48. & Mem. p. 225.

a thing I never remarked, though I have committed *vitriol-lies* to as long a degree of evaporation and ſeparation, as ever M. Geoffroy did.

It is true, I obſerved ſomething of a ſulphur-yellow, but never ſuch a grey muddy matter from pure *vitriol*; whence I conclude, his *vitriol* was impure, or otherwiſe ſullied. He again obſerved, that after ſtanding in the fire 'till gilded, it yielded a larger quantity of it, than if dried to whiteneſs only, and ſtill more, than if taken juſt freſh for the ſeparation of this *mother-lie*. Again, that this *vitriol*, once uſed, yields the ſame a ſecond, a third, and a fourth time, nay, repeatedly, or 'till the whole maſs of *vitriol* employed be thus conſumed and ſpent. Further, that upon each repetition he procured a yellow powder: that the *mother-lie* grows hot with the acid of *vitriol*, ferments remarkably with the acid of nitre, with oil of white tartar, at firſt only ſoftly, but ſoon after alſo in a violent degree: that after drying and ignition in a briſk fire, it again turns ſmeary and fluid in the air.

Now, in order to account for this, M. Geoffroy affirms firſt, that it muſt be allowed to be, in ſome degree, alcaline, as it appears ropy, like a run lixivious ſalt, and violently effervesces and heats with the acid of nitre, like any other alcali: alſo, that this ſalt is only derived from the acid of *vitriol:* and then, that being not only in taſte, though without any remarkable acidity and ſharpneſs, aſtringent, but likewiſe fermenting and heating with alcali's, there may be a proper vitriolic matter ſtill contained therein, ſeparable by accurate repeated ſhootings; or if ſtill withheld, may, in time, ſpontaneouſly bewray itſelf in the yeſt thrown up

up in the courſe of the fermentation: and laſtly, in regard to the cauſality of this alcaline *vitriol*-liquor, he explains himſelf in ſuch a manner, as would make one imagine a tranſmutation of the *vitriol-acid*; but he does not ſay, at leaſt not diſtinctly enough, whence the matter is derived, which we muſt doubtleſs ſuppoſe, for the exhibition of a dry lixivious, and the incorporation of the acid ſalt.

That the acid ſalt of *vitriol* ſhould become, I will not ſay alcaliſed, yet changed ſo as to loſe its nature and eſſence, appears, among other inſtances, from diſtilling oil of *vitriol* upon quicklime, when there ariſes a maſs that entirely turns moiſt in the air: but even hence we ſee there is ſomething which deſtroys not only the mixtion of the acid *vitriol-ſalt*, but muſt alſo give it a body. In ſhort, this change cannot happen without ſome concurring cauſe, and what is here procured cannot properly be held for a changed *vitriol-ſalt*, but for a third thing, ſomething which muſt take its riſe from the two other, namely, the acid ſalt, and an earth.

To give my own thoughts upon this ſubject, we are to obſerve, firſt, that ſuch ſoluble, vitriolic remainder ſhews itſelf on three different occaſions; (1.) upon the lixiviation and elaboration of the *vitriol* from its crude ore; (2.) upon the re-ſolution and cryſtalliſation of a purified *vitriol*, already ſeparated from its ore; (3.) in the uſual way of preparing *vitriol* with iron and oil of *vitriol*.

The ſecond is what gave occaſion to M. Geoffroy's remarks, but which I muſt paſs over. The firſt, of which he makes no mention, is properly within my province, as relating to the *vitrioliſation*, conſequently the hiſtory of the *pyrites*. The third

I have only employed as a kind of auxiliary means towards the diſcovery of the cauſe of this ſurpriſing vitriolic production.

And here, to abide by the firſt, I have found, (1.) That all crude *vitriol-boilings* leave behind a fatty, thick, oleaginous lie, be the *pyrites* prepared either with or without fire, *vitrioliſed* above or under ground, and the vitriol ſoaked in the earth and ſtone, or caked together in the open air.

(2.) It ferments with alcali ſalts, and lets fall a bright brown earth, but never with acids.

(3.) Upon ſetting it by for ſome months out of the reach of the fire, ſomething ſhoots from it like ſmall crumbly grains, plumoſe and aluminous, as was already obſerved.

(4.) But, if the whole be left together to evaporate, without ſeparating this matter, it turns thick like a reſin, and at laſt becomes a grey whitiſh maſs.

(5.) In the courſe of the evaporation, which is performed in the ſoft heat of a ſtove, I once obſerved it heave and riſe, and the glaſs, ſcarce a third full, to become quite filled therewith.

(6.) This grey maſs taken directly, whilſt hardly cold, ferments readily with alcali, but in no ſort with acid.

(7.) Even upon expoſure in the air, it turns moiſt and ſmeary, exhibiting the ſame phænomena with acid and alcali as before.

(8.) Di-

(8.) Diſtilled in an open fire, it yields an acid ſpirit, and leaves behind a bright, brown-red earth.

(9.) This earth ſtill proves moiſt in the air, yet more or leſs, according as it is more or leſs burnt.

(10.) Even after ignition in a crucible, it ſtill attracts, though in a very ſmall proportion, the moiſture of the air.

(11.) The laſt ſeparated aluminous matter, n° 3. diſtilled apart, gives alſo an acid water, and leaves behind a ſpongy, grey, and here and there reddiſh ſpotted cake, which equally turns moiſt and ſmeary in the air, as n° 7.

(12.) What remains behind of n° 3. proves neither thicker, nor more oleaginous than before.

(13.) What remains from the *vitriol*, prepared from iron and oil of *vitriol*, and dried, turns alſo ſmeary, flows in the air, and ferments with alcali, but by no means with acid.

Now, from theſe proofs thus much at leaſt appears; that this oleaginous reſidue, from *vitriol*, does, after exſiccation and ignition, become ſmeary, nay, ſometimes flows in the air; but whether it will ferment with acids, and thus exhibit an alcaline nature, is a different queſtion; not that I would entertain any doubt about M. Geoffroy's experiment, as being made and repeated expreſsly, and not a thing purely incidental, though it is what I could never obſerve: but that it may be exceedingly poſſible, appears, as was above ſaid, from its ſponta-

neous fuming and frothing, and turning, after exſiccation, ſmeary in the air, like an alcali.

Whatever be in that, thus much we know, that this *vitriolic* reſidue conſiſts of two parts, namely, the *vitriol-acid*, and an earth, as appears by an entire expulſion of the acid, by means of a thorough glow; whence it ſeems that theſe two parts were but ſlightly combined, conſequently, that they cannot conſtitute a genuine alcali, as from ſuch the *vitriol-acid* can never be expelled *per ſe:* but again, there muſt alſo be an earth, without which no exſiccation can be procured; and he who conſiders, or rather, manually treats ſalts, with reſpect to their productions, tranſmutations, origination from, and reduction to earth again, will find ſuch phænomena exhibited from a *vitriol-acid*, and an earth; though he may be unable to aſſign the formality, or remote cauſes, which generaliy lie concealed from us in other inſtances.

That this earth is from iron ſeems probable; for to what Homberg † has remarked of an iron fattineſs exhibited by means of a burning-glaſs, and what others credibly relate, of a quickſilver from iron, Dr. Rothe has added ſome weight, in his diſſertation on metallic ſalts: not that I would aſcribe any thing peculiar to iron before other metals, as it is a ſort having only proximately its origin from a crude unmetallic earth, and with which, as one of the coarſeſt, earthy metals, many things may chance to be incorporated.

A brown-red earth, called *caput mortuum*, remains behind from *vitriol-lies*; but then only to be ſo denominated, when no longer containing any thing living and pungent, *i. e.* ſaline and ſapid; con-

† Mem. l'an. 1710, p. 303.

conſequently, is a thing dead and effete, no more to be boiled for *vitriol*, but thrown away as uſeleſs.

Two queries ſtill remain behind, *viz.* (1.) Whether a *vitriol* may not alſo be arſenical, or partake of arſenic: The reaſon of the query is, that *pyritæ* are not without arſenic.

(2.) How the caſe holds with the *vitriol* and its *pyrites*, alſo with the alcaline earth in medicinal ſprings.

A certain ſpring, which I highly eſteem, but leave nameleſs, to prevent the entertaining any prejudice againſt, or diſadvantageous opinion about it, gives occaſion to my firſt query. That it is arſenical is plain, not only from the white ſublimate procured from it, but alſo from the actual arſenical odour, it ſtrikes the noſe withal. Yet, neither on this nor the other circumſtance, is any great ſtreſs to be laid at all times, eſpecially when the arſenic is in ſo very ſmall a quantity, as is the caſe here, that it cannot be ſufficiently examined; for, phoſphorus alſo gives forth an arſenical odour, which I have alſo ſmelled from a lead-proceſs, where nothing arſenical, but ſalts only were employed; and ſalts, ſuch as are in the nameleſs water, may, in their mixed crude ſtate, volatiliſe a little, though not, in their ſeparated ſtate, or not ſo eaſily without peculiar *additions*, appropriations, *&c.*

As *pyrites* generally contains arſenic, this arſenic may lodge in that ſort from which the water may receive its mineral conſtituent portion. The poſſibility of the thing appears from the Friberg

ſchlacken-bad, where ſome arſenic, by means of ſulphur and *vitriol*, inſinuates itſelf into the water, which notwithſtanding, has as good effects, and performs as good cures as any other medicinal water. Not that we are to imagine ſuch waters to hold great quantities of arſenic; it ſometimes ſcarce amounting to grains, nay, not to one eighth of a grain in ſeveral pounds of water, as I have found in the *ſchlacken-bad*.

And though a water ſhould happen to hold a greater quantity, if not to a very extraordinary degree, it ſhould not therefore be conſidered as noxious and poiſonous, but its innocence, nay, uſefulneſs, ought to be judged of by the effects, and not by pre-conceived ſpeculations. It is, however, true, that of all the *vitriols* I have ever examined, I found no one ſort arſenical, though ſuch a thing might be ſurmiſed from ſome *groove-vitriols*, in conſideration of the arſenical admixture in their *pyrites*.

Laſtly, to mention ſomething on the head of *acidulæ* and *thermæ*: theſe certainly, in regard to their *vitriol*, ſulphur, iron, copper, arſenic, alſo their alum, take their riſe only from *pyrites*; the *vitrioliſation* of which looſens theſe parts, and fits them to incorporate with the intercurrent waters, and to render them mineral.

The other contents, either a pure, or a *vitriolated* lixivious ſalt, though the laſt becomes ſuch by evaporation only, are by no means produced, as none ſuch can be procured from *pyrites*. And here principally we have two queries to make.

(1.) How

(1.) How it happens that moſt of theſe waters contain the above-mentioned minerals in a very ſmall quantity.

(2.) How two ſuch oppoſite matters, as a lixivious ſalt and a *vitriol* can conſiſt together, without laying hold on each other.

As to the firſt, we have often water in the grooves, remarkably *vitriolic*; but, ſo far as my knowledge of the ſprings in Germany, England, France, Hungary, *&c.* reaches, no ſuch thing can be affirmed of thoſe at the day, ſeeing theſe diſcover only the leaſt *vitriol*, or other mineral poſſible: which, in ſome meaſure, we may account for from ſuch waters taking their riſe nearer the day, when the more day-water coming to mix with them, they thus become weakened and diluted.

But then, that mineral ſprings ſhould remain of one conſtant yield, and become neither richer in hot, dry, ſummer-weather, nor remarkably ſmaller or poorer in the moiſteſt harveſts and ſprings, we muſt aſcribe to ſuch waters having a diſtant, deep, and not a near origin, not only in reſpect of their mineral particles, but alſo their univerſal watrineſs; likewiſe, to ſuch *pyritæ* as *vitrioliſe* ſparingly and leiſurely: not to inſiſt on their great plenty; as there are ſprings that have continued running for a long courſe of years; which ſhews the ſtock they are derived from to be inexhauſtible.

Hence we exclude all *pyritæ*, vitrioliſing ſo eaſily, ſo richly and ſo quickly, as the round in ge-

neral do, which lie directly under the ſurface of the earth, as thoſe of Altſattel, Almerode, *&c.* For the ſame reaſon alſo we deny the *copper-pyrites*, or copper-ores, as theſe always ſupply a *vitriol*, if not entirely, yet in part coppery; conſequently, a ſomething not to be met with in our medicinal waters.

We muſt therefore have recourſe to *pyrites*, *breaking* in fiſſures and veins, and not coppery; and affecting, if not the cubical, yet the angular figure; which are not, or leaſt of all, coppery, yet vitriolſing difficultly and ſparingly.

As to the other query; namely, how ſuch oppoſite matters, without being thrown up together, and thus continuing in their mixtion and nature, can remain ſeparate and undeſtroyed. This is not the only inſtance we have in nature, being furniſhed with a ſimilar one in the above *vitriolic* reſidue, wherein an alcaline and acid ſalt lie contiguous, and remain at reſt, though at length they are embodied, and diſcover themſelves by a fermentation or heaving: nor again, are we at a loſs to account for it; for the higheſt mineral acid never remains in a ſeparated ſtate, but always united to ſomething; as here in medicinal waters, either to an alcaline or metallic earth. Now, when ſuch waters come to ferment and heave with acid ſalts, we muſt certainly conclude, the alcali therein is neither combined with, nor ſubdued by the acid; and though, by means of evaporation, a yellow earth falls down, ſuch muſt ariſe from the deſtruction of the *vitriol*; and from the falling down of the earth, we may conclude to the preſence of the acid, as being ſeparated from this earth, and only unobſervedly inſinuated into the adjacent alcali;

alcali; and the more ſo, the more it is ſet free from its vitriol-mixtion by continuing the evaporation.

That theſe do no ſooner lay hold of each other, muſt be owing not only to their diſperſion, but alſo to the over-proportion of water. For, as ſoon as only a little of the water is evaporated, ſo ſoon do theſe antagoniſts fall upon each other, after having hitherto remained ſo long in peace. Now, as the acid ſooner, and more firmly unites with alcali than with metallic earths, ſo here the acid lets go the metal under the form of a yellow earth, and combines with the alcali.

Here I mean only ſuch waters, where, along with the *vitriol*, the alcali manifeſtly lodges, as is generally the caſe in medicinal ſprings: but ſhould you meet with *vitriolic* waters, affording no ſuſpicion of an alcali, nor exhibiting any; and yet the *vitriol*, after a degree of evaporation, coming to be deſtroyed, as ſhall ſufficiently appear by the precipitating yellow earth, there muſt be other reaſons of this appearance, or your experiment has not been accurately gone about.

If no formal alcali can be exhibited, it muſt then be common ſalt that preſents its alcali; whereby *vitriolic* waters turn eaſily muddy and ochry; again, if no common ſalt, it muſt be ſomething earthy, without participating of which a ground-water ſeldom is found, to which, if the *vitriol-acid* does not faſten, yet it may become contiguous, ſo as to let fall its metallic earth, which does not hold very firm thereto: and if there is no precipitation, yet waters generally, by long boiling, leave behind an unctuous, fatty, browniſh liquor,

taſting

taſting bitteriſh, ſmelling lixivious, and though not formally alcaline, nor yet viſibly fermenting with acids, but approaching thereto: this appears at leaſt from all our Up-land, and probably too, holds good of the Low-land waters, provided other groſs, earthy, and ſaline parts intermixed, ſtand not in the way of a proper ſeparation and exhibition. Moreover, there is no great difficulty to reſolve a body of ſuch feeble texture as *vitriol* is (which gives in the very air) eſpecially that little of it generally in waters.

Further, concerning the alcaline ſalts in mineral waters, though it be difficult to aſſign their origin, yet there are ſeveral ſprings, from which they may be procured in a quite eaſy manner. For, not to mention common ſalt, as being plentifully to be met with in the earth, and which (a thing well to be obſerved) is the only matter, from which, with the addition of the acid of ſulphur or *vitriol*, a bittter ſalt, like that from *acidulæ*, is procurable by art; eſpecially as ſuch bitter, or ſpring ſalt is to be met with in all *ſoles* or brines, as Profeſſor Lehman, a perſon much converſant in ſalts, has diſcovered: nor to inſiſt on lime-ſtone and gypſum-ſtone, nor what is allied thereto, ſpath, nor cat-ſilver, Muſcovy-glaſs, *ſelenites*, *glimmer*, and the like, as being all of a ſpathy, and ſpath of a calcarious nature, and all, in particular ſpath, which lies by *pyrites*, of an alcaline nature, and with acid capable of putting on the appearance of a ſalt, as we learn from the white *tophus* in the Prudel ſpring at the Carlsbad; I ſhall only propoſe, by way of query, another ſort of earth or ſtone, which the alcali in queſtion may, among other things, be aſcribed to, eſpecially when we come to conſider the buſineſs of the converſion of earths into ſalts,

and

and of ſalts into earths, and of theſe laſt among themſelves; namely, that fatty, black, grey, ſhivery, unctuous earth and ſtone, eminently *breaking*, by *pyrites*, and from which alum is uſually produced, and thus probably of a luty, ſlimy original.

Amidſt certain circumſtances, eſpecially as ſoon as ſuch earth, procured from ſuch ſtone, is laid hold on by the vitriol-acid; or rather, as ſoon as the acid in this ſtone itſelf comes to work; or more properly ſtill, as ſoon as this ſtone comes to act upon itſelf (whereby not only the vitriol-acid by the attraction of the air, but alſo the aluminous earth is formally made; in ſhort, the alum produced not only in its whole, but its parts) there indeed ſuch ſtone cannot arrive to the alcaline earth we are here in queſt of, as in this production in general, not proving ſaline, but ſtubborn, calcarious, or highly cretaceous. And yet, what is this more than a converſion? But, when the vitriol-acid comes not thus in play, as we may learn from the alcali lying quite naked and unſaturated in *acidulæ*, and thence coming to ferment with acids, there indeed the circumſtances, conſequently the difference cannot minutely be made out, but muſt be charged to the ſcore of the difference of elaboration, and other incidental circumſtances: ſo alſo ſuch ſtone exhibits not its habitude to acid, but ſomething, namely, the alcali, according to aptitude rather peculiar than incidental to it. In ſhort, let this ſtone be properly burnt, and the alcali, tho' in a very ſmall quantity, will become manifeſt not only from its habitude to acid, but alſo from the actual exhibition of a bitter ſalt.

But

But here it will be objected (1.) that ſuch waters alſo hold an acid, and thus the alcali lies not naked therein; (2.) that we muſt here mean not an alcali prepared by fire, but a natural ſort; (3.) that even in this formation of alum, an acid and alcali come together, as when one conveys an acid on ſuch burnt ſtone, and yet *there* no bitter ſalt, *here* no alum is produced. As to the firſt, it is true, the alcali is not combined with, but ſtands apart from the acid, which is ſtill joined with the metallic earth, as was ſaid. As to the ſecond, the axiom holds good, that we cannot form any juſt concluſions from what happens above the earth, or by means of art, to what happens ſpontaneouſly in the bowels of the earth: nor, converſely, that what happens not above the earth, or by art, may not happen naturally under the earth, in certain circumſtances, through length of time. Again, here ſerves the experience or obſervation of a calcarious earth, or ſtone, being not only corroded by, but capable of being incorporated with bare water, which ſhall ſtill remain clear and tranſparent: and as to the third, in the inſtance objected, the acid is not firſt produced or formed, but derived, as already formed, from elſewhere; whereas, in the other caſe, it muſt become ſuch in the act of *aluminiſation*, ſo far, namely, as it ariſes, without *pyrites*, from the pure ſtone abovementioned.

CHAP.

CHAP. XIII.

Containing the ſeveral USES of the PYRITES; and, 1. with reſpect to the making of SULPHUR.

PYRITES is worked for ſulphur, either expreſly or incidentally; in the one caſe it is *driven*, or forced off in pipes or retorts, in the other procured in the courſe of roaſting the ores: by the former method, both here, at Friberg, and at other places; by the latter, particularly at the Hartz, as follows, according to Lohneiſs *.

'They take, ſays he, of the ſmall ore, that is, 'both of the ſmall ſweep from the ore of the 'grooves, and from the vitriol works or lies, call-'ed alſo *vitriol-ſmall* and *kernel* †, and ſhoot it on 'a heap one foot high by twenty broad and long; 'on this there is wood laid cloſe together, the 'whole breadth of the ſmall ore, and piled three 'foot high; then on this wood the ore is *ſhot* in 'greater or ſmaller pieces, as it comes to hand; 'and, to one roaſt, are taken between 1500 and '1600 meaſures, each weighing 5 and 1 half cent-'ners: the roaſts are made ſquare, and raiſed nine 'foot high, and covered all over with moiſtened 'ſmall-ore for a large *hand thick*, and ſtruck cloſe 'and firm. From the middle of the roaſt is 'reared a brand of dry wood, reaching quite thro' 'the ore, and over-topping the roaſt. The roaſt 'being

* Bericht vom Bergwerk, p. 80.
† Kernel is the beſt or richeſt ſmall ore.

'being compleated, the ſmelters take from the 'huts a ladle-full of hot ſlags, pour them in on the 'brand, ſet upright in the roaſt: and the wood 'generally burning down in a night's time, the 'ore, if left to itſelf, will continue burning for 'eight, nine, or ten weeks. There is much *ſul-* 'phur procured at preſent from the Rammelsberg 'ores, of which the old workers knew little or no-'thing, and much more may ſtill be obtained, by 'proper management.

'For inſtance, thus the covers of the roaſts be-'ing, as is ſaid, burnt down, they become ſoft 'by the great degree of heat; and then, with a 'piece of timber, they are ſtuck full of round 'holes, for the *ſulphur*, which retires into them, 'to be laded out with iron ladles. The *vitriol-'ſmall* and *kernel* here employed, ſhould ſeem to 'promote the caking of the covers, to prevent 'the more eaſy evaporation of the ſulphur.'

Inſtead of the above holes, they now make certain ſinkings, or pits, about two feet in diameter, by a foot and a half deep, which are ſtruck firm with *vitriol-ſmall*, and ſtand aſunder the length of one diameter. Now, the roaſt burning from below upwards, the *ſulphur* retires into theſe pits, out of which it is laded with iron ladles into moiſtened tubs. It would require no fining, did not ſome of the *vitriol-ſmall* drop into it in the lading, and thus taint the *ſulphur*. The firſt fining is performed in iron coppers, wherein the *ſulphur* melts; and after the coarſe, impure parts are ſunk to the bottom, it is caſt in moulds; what thus remains behind, is in the ſecond fining treated like the crude *ſulphur*.

The

The method of *working ſulphur* expreſly at Friberg, M. Roſsler * deſcribes thus: 'For the purpoſe, there muſt be a driving and a fining furnace, both to be properly proportioned. The ſulphur, or driving furnace, is built in length, in ſuch a manner, as between the two front, or head walls, to admit of either eleven, thirteen, or fifteen pipes, to reach acroſs from wall to wall; alſo lower, there are either ſix, ſeven, or eight pipes, placed at a height; over the ſpaces between theſe, another row of five, ſix, or ſeven pipes, alſo at a height, ſo that each pipe may come to be within the reach of the fire, and become ignited. The width of this furnace muſt be determined by the length of the pipes. Over the pipes, from one head or front wall to the other, is turned or caſt a flat arch of tiles, with a number of holes left, of the ſize of a ſmall arm, for diſcharging the ſmoke of the wood. The pipes are made of good ſtuff or clay, and two and a half inches thick, and nine inches wide at the mouth, which is flat in the under, and ſomewhat round in the upper part, and to be ſo made, that a clay plate may be ſhoved down over it, and again removed occaſionally; from the mouth they run tapering off to the other end, where the *ſulphur* runs out, leaving an aperture only of an inch. Behind, where the *ſulphur* runs out, there is left on the wall a ſettle, whereon the lead-pans may ſtand to receive the ſnouts of the lower pipes; and for each upper pipe a ſmall wall is raiſed for their pans. The pans are ſquare, with a flat half cover, reaching half way: ſome cold water is put into the pans, for the *ſulphur* to run into and be quenched in. The furnace is heated with billet-wood laid on a grate, through which the coals may fall down. You muſt be well acquainted

* Berg bauſpiegel. l. iv. cap. 16. p. 155.

'quainted with the nature of your *pyrites*, as all 'of them cannot equally with profit be worked for 'ſulphur; alſo know, what quantity may be lodg-'ed in at once and burnt in eight hours. When 'eleven pipes are employed, for the week about '126 centners of *pyrites* muſt be worked, eighteen 'centners for the twenty-four hours, and ſix cent-'ners worked each time for eight hours. From 'pyrites of an ordinary *yield*, there may in a week 'about five and a half centners of fined *ſulphur* be 'procured, the centner of *pyrites* reckoned at four 'and 1 half pounds. The pipes, as was ſaid, muſt 'be made of good ſtuff, and not overcharged, as 'the *pyrites* is apt to ſwell and heave, which 'might endanger the pipes. Alſo the arch, next 'over the upper pipes, to be left open, there be-'ing then a greater degree of heat, and a better 'drift of *ſulphur* procured.

'The crude *ſulphur*, when there is a quantity of 'it together, is done out of the lead pans into ob-'long fining pots of iron, which are lodged in the 'fining-furnace, and fitted with clay-helms and 'earthen receivers; and thus the *ſulphur driven* 'or forced off, and then from the receivers tapped 'off into other pots, wherein it is ſuffered to cool 'a little; after which it is caſt in moulds, in long 'rolls, and packed up in veſſels: in the fining 'there is a fifth part waſte. In the fining-pots, af-'ter forcing off the *ſulphur*, there remains behind 'the droſs, called *ſulphur-ſlags*; which, whilſt ſtill 'hot, are to be removed with an iron ladle. The 'pyrites thus worked is thrown aſide, and ſome of 'it uſed as *additions* in the operation of *crude-'ſmelting*, and the reſt of it boiled for vitriol; but 'what is deſigned for this laſt, muſt lie for thir-'teen weeks in the open air before it can be uſed.'

The

The method of *working for ſulphur* at Dylta in the Province of Nericia in Sweden, we ſhall next deſcribe. This is is one of the greateſt works for *ſulphur* in the whole kingdom; and here they alſo boil for vitriol and alum. The matters, from which all theſe things are drawn and prepared, are a yellow-greeniſh, dark-ſhining, ponderous *pyrites*, not *breaking* there in the high-land, nor at great depths, but beneath the under-turf earth in low-lands or levels, alſo in the firm rock or ſtone; and lies in layers or *ſtrata*, that is like a *flat-work*, at between three and four fathom under a cover of common ſtone, about a finger thick. When they would work upon it, they clear away all to the ore, on which they lay wood to burn, and on the heated ore pour cold water, which makes it the eaſier to work; after which they break it in pieces, and convey it on a heap together: and as all this is done in the open air, they can only work at it in the ſpring and ſummer ſeaſons; for, in winter and autumn, the groove, which is very wide, and ſtands uncovered, is generally half full of ſnow and rain. In the working ſeaſons, twenty large iron pots or retorts, weighing between eighteen and twenty-one centners, are filled only a third, as the *pyrites* greatly heaves by the heat; and theſe pots are placed in a vaulted furnace, in manner that the bottom of the one ſhall touch on the neck of the other; and, on both ſides of the furnace, are ten apertures, five in the upper, and as many in the under row. Then the iron-receivers are fitted on to the pots, and well ſecured with luting; and fire being made under the pots, the coarſe *ſulphur* is forced off into the iron-receivers at the rate of four and a half centners in twenty-four hours, according as the *pyrites* happens to be richer or poorer in *ſulphur*; whilſt ſome of

the fineſt parts, exuding through tne pores of the iron, and coagulated by the cold air, yields pure *drop-ſulphur*. Whence, in ſummer-weather, every morning about ſun-riſing, in harveſt and winter every evening, the *ſulphur* is removed out of the receivers, and the deſulphurated *pyrites* out of the pots, and replaced with freſh as before. The *ſulphur* is again melted in an immured pot over a gentle fire, in order to its fining, and then caſt in the uſual moulds. The deſulphurated *pyrites* is laid on heaps in the open air, and the following year, according as it happens to be moiſtened by rain, begins to take fire, and burn ſo long, till all the *ſulphur*, ſtill remaining therein, be quite conſumed. Thus far the more antient workers went; but the new, diſcovering that the deſulphurated heap was impregnated with vitriol, and the more ſo, the longer it lay expoſed, conveyed this refuſe into large veſſels, poured water thereon, and made a lie. But at preſent, it is put into lead-pans, and boiled for ſome hours with water: from the former, this lie is conveyed into other lead-pans therein to boil, till the vitriol-maſter ſees it is fit to ſhoot, who muſt have the dexterity of attempering it by pouring in ſome of the firſt lie. Now, after the lie is boiled, or ſoaked to a proper degree of thickneſs, the fire is lowered, and the lie poured into coolers, there to ſtand, till the vitriol ſhoots to cryſtals on the birchen twigs put therein. What remains unſhot, is again boiled along with new deſulphurated and vitriolated *pyrites* in the ſecond pans, and further brought to cryſtalliſation. The number of huts is two, of pans to each hut four; always two for crude lie, and two for good lie; each weighing thirty centners, and ſtanding on large iron grates, that they may come by no damage: and yet the pans for the good lie laſt not above five or ſix years, and thoſe for

for the crude, not above three; in regard the earth burnt to adheres ſo firm to the lead, that, if never ſcraped off, the lead muſt needs melt. Now this lie, after all the vitriol is ſhot and removed, the alum-boiler takes to his hut, pumps a water thereon holding metallic particles, and adds a lie of wood-aſhes, whereby the green vitriolic colour is diſcharged, and the white colour of alum procured; it is boiled over again for twenty-four hours in lead-pans, and afterwards ſuffered to cool and ſhoot; then the alum is fined and done: the remaining lie is put into a large veſſel, and after ſtanding for eight days, it concretes as a cryſtal into the figure of the veſſels, and afterwards is broke in pieces, and is ſaleable, or fit for the market. There paſs at leaſt between five and ſix weeks, before a veſſel which holds about eighteen centners, can be filled with alum; and when boiled in harveſt or wet weather, or left too long in the veſſel, it generally turns of a ſomewhat greeniſh caſt *.

II. To the boiling for VITRIOL.

At the ſulphur-works there is generally a *vitriol-work* too, as the burnt *pyrites* is well fitted for that purpoſe; though there is alſo a *vitriol* boiled from a *pyrites*, from which never any ſulphur was made. Such a work requires a lead-pan ſeven feet long, ſix feet wide, and about two feet deep, weighing between twenty-four and twenty-ſix centners; then three lie-trunks, eleven feet ſquare, and two feet high. From the burnt *ſulphur-pyrites*, which give or reſolve in twelve weeks time, there are ninety-ſix centners run into one trunk, and there lixiviated with water, and the lixiviated water collected in one

* Leopoldi relatio hiſtorica de itinere ſuo ſuecico. An. 1707. ad Dr. *Woodwardum*, p. 84. ſeq.

veſſel, there to fine: then this lie is poured into the lead-pans, and boiled, and freſh lie always gradually poured in, that the pan may ſtill remain full; according as the lie is ſtrong or ſmall, more or leſs *vitriol* is procured; generally, a pan amounts to between ſix and ſeven centners. In the boiling, care is to be had, that no ſort of tallow, oil, butter, or greaſe, come nigh it, otherwiſe the *ſod* or boiling is marred; and when it begins to have a ſkin, it is enough, and then the *ſod* is let out into a large trough, wherein it may alſo fine; from this it is ſhared out into ſhooting-troughs, one of which generally yields one half centner of *vitriol*. In the ſhooting-troughs pieces of wood are ſuſpended, whereon the *vitriol* may hang and ſhoot; the remaining *ſod*, from which the *vitriol* is ſhot, is poured again into the pan to a freſh lie. At times, freſh roaſts muſt be uſed for it, and that every week, for the lixiviated *pyrites* to be again burnt, and again lixiviated; they are ſo often uſed, 'till at laſt they muſt be ſifted, to ſeparate the ſmall parts, which are of no more ſervice, and though fluxile in ſmelting, yet give no *ſtone* or regulus. Sometimes the *vitriol* refuſes to ſhoot duly, and here the maſters uſe a peculiar piece of ſkill, which they will not readily diſcloſe. In other places, where no ſulphur is made, they uſe new and old *pyrites*, of which they make ſeven roaſts, each at forty ſix centners; employ four large lie-trunks, and procure from the ſeven roaſts in a week about forty centners of *vitriol*, for which there muſt be every week employed above one hundred centners of new *pyrites* *.

III. To

* Roſler's Berg-bau-ſpiegel, Lib. VI. c. 17. p. 156. ſeq. Lehneiſs, p 329.

III. To the making of ARSENIC.

Arſenic is made partly from a peculiar *pyrites*, or cobald, partly from a ſort, amongſt which tinſtone is found, partly from the ſmalt-cobald, partly alſo from the gold and ſilver holding *miſſpickel*, or white *pyrites*; and all theſe cobalds or *pyrites* muſt previouſly be parted from the barren minerals, by ſtamping and waſhing, and made into a pure *ſludge*, from which afterwards, by means of roaſting and burning, the *arſenic* is forced out in the fume, and catched. Formerly, the furnace had one ſmall aperture, by which the fire was kept up, and the *ſludge* ſtirred; was internally about eight feet wide, and ſomething longer, and two feet high, like an oven, with an arch over it, and on that a long horizontal paſſage, or funnel, of maſonry, eighty-eight feet long, of the height of a man, and three feet wide, called the *meal funnel*; on the end of it was erected a pipe for diſcharging the ſmoke of the wood and the *arſenic* fume; at proper diſtances in the funnel were windows or apertures a foot ſquare, which were ſet open at taking out the *meal*. Now, when a *roaſt-work*, or quantity of *ſludge*, was burnt in the furnace, after being firſt well ſtirred, the *arſenic* or fume being retired into the horizontal funnel, fell, at length, like a meal, to the bottom, and, in part, adhered thereto. Upon the furnace's cooling a little, the *ſludge* was drawn, and replaced with other, which was roaſted and burnt ſo long and ſo much, 'till all its wildneſs was forced out, as was done to the firſt: and thus they proceeded, 'till they were to remove the meal from the long funnel, which was done by perſons whoſe faces were bound up, eſpecially the noſe and mouth, and who had before ſwallowed ſome bacon: but at

preſent they uſe a furnace, with a cavity and two mouths, and divided in two parts, and having over the ſmoke-vent ſuch another paſſage or funnel, as above deſcribed, though not all of maſonry, but partly of wood, nor quite ſtraight, but with three or four crooks or windings, againſt which the arſenic-fume may ſtrike, and the meal ſettle. The meal, in order to be fitted for market, muſt be ſublimed like a cinnabar, which is performed in a hut, ſomewhat high and open above, like a roaſt-houſe, wherein is built an oblong, vaulted furnace, about three feet high from the earth, and ſo long, that three plate-hoods, the width of each aſunder, may ſtand thereon. Above, in the vault of the furnace, three round holes are left with each a diſh of caſt-iron, and on each diſh an iron hood of plate, below ſo large and round as to fit the diſhes, and tapering to an aperture of the ſize of a man's arm. After ſecuring the above hoods on the diſhes, a quantity of the *arſenic*-meal is ſhot through the aperture into the diſh, fire made in the furnace, and the meal directly ſublimes into the hoods, being often ſtirred in the diſh, by paſſing a ſtick through the aperture; and when a quantity has ſublimed, they convey in more meal, 'till the hoods become ſufficiently charged, and generally they let the fire in the furnace go out every evening, the aperture always remaining open: but the operators muſt bind up mouth and noſe in charging and ſtirring the meal. Now, in order to procure yellow *arſenic*, amongſt three centners of meal, between two and four pounds of ſulphur are added, which being ſublimed together, a beautiful yellow *arſenic* is procured *. Thus far M. Roſsler.

IV. To

* Id. ib. Lib. IV. c. 18. p. 157. ſeq.

IV. To the operation of CRUDE-SMELTING.

The operation of ſmelting ores is the ſeparation of the metals, firſt, from the parts, reducing metals to ores, namely, the ſulphur, arſenic, and the unmetallic earth, intimately lodged in the ore-mixtion; and beſides, from unmetallic, ſtoney, earthy matters, externally adhering thereto, and incapable of being waſhed therefrom. With us at Friberg, this operation is principally two-fold, namely, (1.) the *crude-working*; (2.) the lead-working, from which afterwards flows the copper-working. The *crude-working* is that wherein the ores in their crude ſtate, that is, not only with the adhering unſeparated mineral matters, but alſo in their unroaſted ſtate, are lodged in the furnace, and ſmelted with ſerviceable, fluxile ſlags, and the beſt or pureſt part of them brought to ſome degree of concentration, or to a regulus, called *crude-ſtone*. The lead-working, to which the above crude-ſtone is taken, after a previous roaſting for three or four times, and the ore, employed therein, and which is moſtly *glitter* or lead-ore, and rich ſilver-ore, is not only well cleaned, by picking, ſtamping, and waſhing, but has alſo undergone a number of roaſt-fires, and is well ſeparated from the ſulphur and arſenic. My only reaſon for comparing both theſe operations together is, that in the firſt, the ores are unſtamped, unwaſhed, and unroaſted, but in the ſecond, well parted and roaſted, without making any diſtinct head of our copper-working, as it coincides with, and alſo flows from the lead-working; where, namely, the *lead-ſtone*, that is, the crude copper cake, or regulus, ſettling down from the former, alſo after repeated burnings or roaſtings, when it comes to be denominated *copper-ſtone*, is

firſt ſmelted, and brought to black-copper, and this, at length, after ſeparating or draining the ſilver, made pure or fine. Here I have only to make mention of the crude-working or ſmelting, as *pyrites* is uſed therein, and is, not only in this caſe, the principal agent, but alſo, in regard to its other uſes, for ſulphur, vitriol, and arſenic, here the moſt important thing.

Now the ores, when landed at the *day*, are firſt picked and ſorted; what is quite clean and pure, as lead-glitter, black-lead; or very noble, as red-goldiſh or white goldiſh (though theſe are not always quite pure) is roaſted, and thus directly taken to the lead-working; what is quite barren, rocky, and unyieldy, is thrown away. Not only in this picking, but alſo in veins, there is procured much of a middle degree of goodneſs, holding neither much in noble nor ignoble metal, but yet not to be entirely thrown away; for inſtance, firſt, highly rocky or ſtoney mixt-work, as quartz, ſpath, *kneiſs*, horn-ſtone, cat-ſilver, Muſcovy-glaſs, glimmer, and lime-ſtone; then alſo, in general, with us at Friberg, mock-leady matters, wherein, notwithſtanding ſomething of a good ore, in particular glitter, copper-ore, and even nobler matters, either in eyes, or interſperſedly, or in the moſt tender fibres, and which can in no wiſe be ſeparated with profit. For, to employ ſtamping and waſhing thereon, would not quit the trouble, or the metal would be waſted and loſt, eſpecially in the caſe of tender interſperſed noble ſpangles; and equally unfit would ſuch prove for roaſting, as by that means the rocky matters, which here cauſe the only inconvenience, would not thus be removed or corrected. Now, in order to work ſuch ores, the method of *crude-working* was deviſed, and is, hitherto,

therto, found the beſt means for that purpoſe; and therein the *pyrites* is the principal inſtrument, as by its means the heap-work, wherein the metal lies widely diſperſed, is, by procuring the *crude-ſtone*, concentrated or brought within a narrow compaſs, and afterwards this ſtone duly worked by roaſting and ſmelting, for procuring the metal-yield; and after repeated roaſtings gives forth its ſilver by means of the lead-working, amidſt leady ores, and the like *additions*; but its copper in a crude, ſtony form, called *lead-ſtone*; which laſt muſt by repeated roaſtings be reduced to *copper-ſtone*, and this again, by ſmelting, to black copper, before it can be made pure and fine. This crude-ſtone, with us at Friberg, generally contains between 2, 3, and 4 pounds of copper, and four loths of ſilver, and is accordingly doſed with *additions*. Now *pyrites* either lodges already in the ore, thus to be treated in its crude ſtate, eſpecially in coarſe veins; or is added on purpoſe, as found neceſſary; or is entirely wanting, as generally in noble veins: and here it is ſo much the more needful to be added, as where no *pyrites* is to be had, or proves too expenſive to be conveyed to the ſpot, moſt of the ore of ſuch places, which is commonly interſperſed with metallic ſpangles, very thinly ſown, and, on that account, neither to be waſhed nor roaſted, lies uſeleſs and unworked.

That the *pyrites* promotes at leaſt the flux of ores, or rather of their rocky, ſtony, and earthy admixtures; or briefly, helps to ſcorify and reduce them to glaſs, is its known effect in the operation of *crude ſmelting*. But when ſuch rocky admixtures hold good ores, as of lead, copper, and the like, the uſe of *pyrites* is ſuperſeded, as the above

are

are of themſelves ſufficiently fluxile: and that it is of no manner of ſervice to rocky matters alone, may eaſily appear, upon doſing barely with *pyrites* ſuch matters, were they without all eyes of ore, and were neither ſoft ſlags, nor any leady additions employed therein. And thus *pyrites* aids, or aids not, according as itſelf is or is not aided. It is in itſelf ſtubborn, yet becomes ſoft and flowing, according as it is treated or doſed: whence it is neceſſary to conſider the refractorineſs and eaſineſs of ores in general to flux: and 'tis owing either to the ores themſelves, or to their mineral admixtures. In themſelves, *glitter*, white and green lead-ores, antimony and yellow *pyrites* or copper-ores are ſoft-flowing: but white *pyrites* more ſtubborn, yet ſmelting in a briſk fire, even when unſtripped of its arſenic: more ſtubborn is the yellowiſh *pyrites*, which apart difficultly or not at all cakes: moſt ſtubborn of all is mock-lead, and next, the earths of *pyrites*, cobald and biſmuth, or their *capita mortua* or remainders: yet thoſe of the yellowiſh more than thoſe of the white; as the former hold more metallic, namely martial, but the latter, more unmetallic earth: Thoſe of cobald and biſmuth are highly unmetallic (ſo far as our experience hitherto goes) and hence not to be fluxed without ſalts, as we learn from the *ſmalt-glaſs*: and as ores hold theſe three metals, lead, copper, and iron, they in proportion prove either hard or ſoft flowing, as theſe metals themſelves prove: for it is known, that unmetallic earths flow moſt difficultly; iron, with difficulty; copper, with more eaſe, and lead, with moſt. In regard to their mineral admixture, all ores are properly ſtubborn; though quartz, compared with any other, ſcorifies *per ſe* with the moſt eaſe; but with *additions*, particularly lead,

alſo

alſo in ſome meaſure arſenic, quartz and ſpathe, are very fluxile: much more ſtubborn are *glimmer*, Muſcovy-glaſs, talc, cat-ſilver, ſhiver and horn-ſtone; moſt of all lime-ſtone, gypſum, alabaſter and chalk. All which particulars I have learned from the proofs. It remains to be enquired why *pyrites*, which is properly of the ſtubborn ores, is a flux, and in what circumſtances. *Pyrites* is three-fold; yellowiſh, yellow and white; or iron, copper and arſenic *pyrites*. The white or arſenic *pyrites* is quite unfit for the operation of *crude-ſmelting*, and hence kept from it as much as may be; in regard its arſenic eats away and ſcorifies the lead, which is already amongſt it either in eyes of *glitter*, or lodged in the ſoft leady ſlags, or otherwiſe added thereto, as is well known of both theſe bodies: or again, when the arſenic has nothing to do with lead, it ſeparates with difficulty, or not at all from its earth (as the *crude-working* is a ſtrong ſmelting fire, wherein it directly cakes therewith, and rather requires a ſoft roaſting fire for its ſeparation) conſequently the earth cannot ſcorify, as it ſhould, to anſwer the end of *crude-ſmelting*. Again, this inconvenience happens, that the arſenic, lodging in the iron of the *pyrites* earth, will not be ſeparated from it in the following lead and copper workings, but is ſtill to be ſeparated in that arſenical, irony maſs, called *ſpeiſe* and *leg*. Further, its earth is ſo crude, as to become, if not unſerviceable for ſcorification, the principal thing here intended, yet not ſo eaſy-flowing; eſpecially as the white *pyrites* is ſo overdoſed therewith: and again, it gives none, or but an arſenical, impure *crude-ſtone*, or regulus.

But the yellowiſh and yellow; or, as they are cal-

called at Friberg, the ſulphur or iron *pyrites*, and the copper-ores are what deſerve particular mention here for the operation of crude-ſmelting, and moſt peculiarly, the yellowiſh, as what ſo completely anſwer, as to compenſate their want of copper: Though indeed it were better, were the common *pyrites* not only coppery, as it generally is at Friberg, but alſo were copper ore added; as then we might expect a *yield* of copper, to help to compenſate the charges in working; and in ſome circumſtances, indeed, where the work ſhall prove hot and refractory, cannot be omitted without loſs in ſilver-yield, but in itſelf, and for promoting the principal end of this method of working; that is (1) For the ſcorification of the rocky, ſtony, and earthy matters. (2) For making the *ſtone* or regulus, and concentrating the ſilver, it cannot be conſidered as abſolutely neceſſary; as it promotes not the firſt; and as to the ſecond, lead is ſufficient; which is already in the ore in *glitter-eyes*, as coarſe veins are never without them; or leady *additions* may ſupply that want for noble veins; where not only *glitter*, but alſo *pyrites* is generally wanting.

What the *pyrites* contributes in the operation of *crude-ſmelting*, is to flux and ſcorify the ſtony and earthy matters, to ſeparate the ore from them, and make it give forth itſelf in what is called the *ſtone*, or crude regulus. Now as *pyrites* conſiſts of ſeveral parts, as ſulphur, arſenic, iron and copper, we muſt enquire which of theſe it is, that promotes the above effects. The arſenic is here to be ſecluded, as corroding lead, tainting ſilver, and as encumbering, nay proving detrimental to the ſcorification. Copper is in this caſe to be conſider-

ſidered rather as a *patient*, and ſo far good, than as an *agent* in any degree: conſequently, there remain only ſulphur and iron, which from all circumſtances and experiments we may conclude to be the principal agents in the buſineſs of the ſeparation, precipitation, ſcorification, or by whatever other name the proceſs be denominated. That the ſulphur contributes not a little, we may certainly conclude from deſulphurated *pyrites*, never yielding any *ſtone* or regulus; and ſo being unfit for the principal view of this operation. Its efficacy appears chiefly on the rocky, ſtony, and earthy matters, adhering to the good ore, or wherein rather the good ore lies entangled. The large quantity of crude, unmetallic, unfluxile earth, which is not to be forced by the addition of ſoft flowing ſcoriæ, wants ſomething, which, with the aid of the ſulphur of the ore itſelf, may macerate, ſoften, diſſolve, and bring it to ſcorifaction; an effect depending certainly on the acid ſalt of the ſulphur: but though ſpirit, or oil of vitriol act little or nothing upon ſtony and earthy matters; yet we are not from the effects of bodies in their ſeparated, to conclude to thoſe of their mixed, ſtate: oil of vitriol, or of ſulphur, as diſtilled from vitriol or ſulphur, has a different habitude from what it has, while lodged in the ſulphur, and combined with the inflammable earth, and ſtill as different as it; nay, the ſulphur itſelf ſtands in the *pyrites mixtion*.

As to the ſecond, the iron; its neceſſity of cooperation appears clearly hence, that (1) The ſulphur is, in its ſeparated ſtate, entirely unfitted for the proceſs of ſmelting, and would only burn away too ſoon. (2) That in another, even a combined

ſtate;

ſtate; for inſtance, in antimony, where there is certainly no want of ſulphur, it would not once work in due manner on the rocky matters; ſince the ſulphur in the antimony does not by far ſo eaſily ſeparate from its ſemi-metallic earth, or regulus, as in the *pyrites*, from the iron-earth, and thus would fail to exert a due degree of activity; not to mention, that the ſulphur ſhould help to ſcorify in the manner the iron does. Beſides, the iron has to do with ſomething more than the unmetallic earth, namely the *ory* matters; which laſt cannot, or, at leaſt, not ſo well, be affirmed of ſulphur; namely (1) The *pyrites* iron, under the direction of proper *additions*, eſpecially leady ſlags, alſo leady ores, helps to make the *ſtone*, corroded by the ſulphur, ſoft and fluxile, and at the ſame time becomes itſelf ſoft and fluxile therewith, that is, a glaſs or ſlag. And this proceeds (1) From the eaſier *terrification* of the *pyrites* and iron itſelf: but the terrification, or reduction of metallic bodies to earth, is the high way to their vitrification, and ſcorification, is a ſpecies of vitrification. (2) By this means, the good ore, diſperſed and ſpread abroad, and as it were immured in the rock and earth, is ſet free and fitted for metalliſation. (3) The iron, which before was a captive to, but now is releaſed from the ſulphur, ſtrikes the ſulphur and arſenic out of the ore; nay ſwallows them up, ſo that the metal is thereby freed from theſe groſs impurities, or precipitated, as a regulus out of antimony. All which internal elaborations, marked under theſe three heads, we are to ſuppoſe to happen inſtantaneouſly, or with a quickneſs equal to the violence of the fire. But as no ſeparation and precipitation happen without the *ſeparant* entering into the *ſeparand*; ſo here all the pyrites-iron goes not into the

the ſlag or ſcoriæ; nay moſtly, or in an unknown proportion, combines with the *crude-ſtone*, as being ever found to be irony.

Now from what has been ſaid, we may form a judgment of a *crude-ſmelting*, wherein ſometimes iron-ſtone, ſometimes real or corporal iron itſelf is employed; of which, among others Lohneiſs makes mention. It is true, we cannot with proper grounds ſpeak of ſuch a method, if we are unacquainted with the whole doſe of *additions*, and with the ore: as little will I affirm, that in ſome circumſtances it may not hit; yet not be unattended with great difficulties, not eaſily ſurmountable. Though thus much I ſee from my own experience, that iron very readily *regulates* or metalliſes *glitter*, as proving here the moſt adapted *ſeparant*. But (1) Our buſineſs, eſpecially in the matter of *crude-working*, is not with pure *glitter*. (2) Should the iron ſupply the place of *pyrites*, nay, have a better effect, the ſtony matters would remain untouched, as being to be fluxed by the ſulphur, which is in the *pyrites*, but not in the iron. And laſtly, we ſhould conſider how it affects the goodneſs of the copper and lead. With the iron-ſtone to procure the principal end of the *crude-working*, which conſiſts not only in ſeparation, but in ſcorification too, the more art is requiſite; in that this laſt, on the ſcore of its incorporated ſtubborn crude-earth, and impurity, wants for itſelf the proper aids and helps. Briefly, it holds quite otherwiſe with the *pyrites* iron, than it does with ſmelted iron and iron-ſtone. In the *pyrites* it is not only adapted in a certain manner by nature, but becomes more ſo in the courſe of the operation itſelf; turning to a ſpongy, ſubtle earth, both receptive,

and

and operative; a thing not to be expected from iron-ſtone. And he, who has experienced the different habitudes of bodies in their ſimple, ſeparated and mixt ſtates, will view artificial iron, and the iron-earth of *pyrites* in different lights.

CHAP.

CHAP. XVI.

Containing, I. The hiſtory of the Heſſian PYRITES, called *Terra martis Haſſiaca.* Communicated by M. Roſinus.

GREAT Almerode, a conſiderable village in Lower Heſſe, three miles from Caſſel, and five hours ride from Munden, lies in a very mountainous, and almoſt the higheſt part of Heſſe, and is encompaſſed on every ſide, partly with very tall foreſts, partly with very high mountains, among which laſt the Weiſſner and Herſs, or more properly Hirſchberg, are the principal. The Weiſſner, which is the higheſt in all that country, riſes near the village of Ludenbach, an hour's ride from Great Almerode, and contains a large inexhauſtible ſtore of ſtone-coals, which are there dug in two different places, and conveyed to Altendorff for boiling ſalt: beſides, on its top, which is quite a plain, a mile in compaſs, many peculiar herbs grow, not readily to be met with elſewhere, alſo good paſture graſs. The Hirſchberg, which is cloſe by Almerode, abounds much with bituminous foſſile wood, or wood-coals, as they are called, alſo with plenty of good bituminous alum-ore, for which two alum huts are built at its foot. The ruggedneſs of the country, and inclemency of the weather, thence ariſing, prove prejudicial both to the agriculture and horticulture about Almerode, the garden-fruits arriving very late there to their perfection and maturity; as I once remember

ber to have ſeen there, about Michaelmas, a tree with ripe cherries upon it: tho' whatever the country about Almerode may ſeem to want in this reſpect, is ſufficiently compenſated by other advantages; among which we may chiefly reckon the various ſorts of clays found there, and called ſometimes *crucible* earth, ſometimes *pipe*, and ſometimes *pottery earth*, according to the various uſes they are put to. The pipe-earth is moſtly employed by the tobacco-pipe makers of Almerode, Caſſel, and chiefly of Munden. The crucible-earth, worked at Almerode itſelf, gives, by mixing amongſt it a coarſe, dry ſand, thoſe crucibles and retorts, which, for their ſtanding the fire, are famous all over the world, and with which thoſe of Almerode carry on a conſiderable traffick, by ſending yearly whole ſhip-ladings of them to Bremen, Holland, England, Dantzick, Riga, and other Parts. From the pottery-earth, beſides the common earthen veſſels, are made thoſe ſtone-bottles, which are yearly ſent in large quantities to Pyrmont, there to be filled with water, and conveyed thence far and near. Among all the abovementioned ſorts of clay or earth, are alſo found various kinds of *ſulphur-pyrites* kidneys: thoſe in the white pipe-earth appear in various angular forms; and, as the clay-diggers affirm, are eſſayed for ſilver and found *yieldy*. Upon breaking them, they often appear white like the arſenical *pyrites*, and as it were, of a ſilvery caſt; are remarkably ponderous, and either do not at all, or at leaſt it is in a very long time, and, with the greateſt difficulty, they crumble in the air; as I have had ſome expoſed for ſeven or eight years, and in all that time, only ſome ſmall vitriolic efflorescences obſerved on the upper ſurface.

face. In this pipe-earth, which is dug very deep, are ſometimes found foſſile galls over the *pyrites*, or at leaſt foreign fruits entirely reſembling galls. In the greyiſh crucible-earth are alſo found *ſulphur-pyrites*, though ſeldom, and in ſmall bits and grains only, but which the crucible-makers carefully pick out from among the clay, becauſe if left behind, they would render the veſſel, made from the clay, perforable in a ſtrong heat, and unſerviceable: of this *pyrites* the workmen affirm it reſolves in the air to vitriol: tho' very ſlowly, the dark grey potter's clay is properly that earth, which holds the famous *minera martis ſolaris*, thus magnificently ſtyled by Glauber. The place, where theſe *pyrites* are found, is at the foot of a hill, not far from the village; where, together with the ſaid potter's clay, in which they lie ſtrewed up and down with ſome other *coagula* or *druſæ* of Muſcovy-glaſs, they are dug out at a ſmall depth, almoſt at the day, and found in ſuch plenty, that I myſelf, and two other perſons, had in about one hour and half, with eaſe, gathered a centner of them: their figure generally, as that of the like *coagula*, is more or leſs round, alſo oval; externally they are of a blackiſh caſt, but internally of yellowiſh, moſt frequently of a paler, but ſometimes alſo of a darker hue than other *pyrites*; and in gravity and hardneſs differ nothing from the other *pyrites* abovementioned. Only in this they ſeem to have ſomething peculiar, that they not only entirely, but alſo (which chiefly deſerves to be conſidered) very ſoon reſolve ſpontaneouſly in a moiſt, open air, and crumble to a greyiſh powder, which after elixation and evaporation, yields forth a green iron-vitriol, and an acid liquor. 'Tis true, I am acquainted with *pyrites* enough, which in time change to a vitriolic ſalt; as ſuch are found in

great variety near Almerode, alſo in the clay and blue marl pits of Munden, and other adjacent places; yet I know of none undergoing ſo ſpeedy a change as thoſe Almerode *pyrites* found in the potter's clay: ſince I have been aſſured by perſons of credit there, that being dug freſh in ſummer weather, and moiſtened a little by means of a warm rain, and afterwards lodged in a ſhady place in the open air, they vitrioliſe in a few days Laſt ſummer I obſerved a phænomenon entirely uncommon, and perhaps peculiar to the *minera martis ſulphurea*, rather than *ſolaris*, of Almerode: namely, that having placed a large wooden trough with this mineral, moſt of it being already become a vitriolic powder, on a floor four ſtory high, which was indeed dry, but ſufficiently expoſed to the air, fanning though the open windows. In the beginning of the ſummer, I unexpectedly obſerved this matter to become moiſt, and gradually ſtill ſofter, nay laſtly, fluid, and begin to trickle through a ſmall rent in the trough. Upon which this fluid matter, together with its thick bottom, was put into other veſſels, and by the addition of more water fully elixated. The clear lie being poured off, was put into open, flat glaſſes, and committed to the gradually increaſing ſummer heat, till become quite dry: by this means I in ſome time procured from this liquor a green vitriol, and a yellowiſh dry bottom or ſettlings, eaſily pulverable. But in the immediately ſucceeding autumn this dry bottom was deliquated anew, and changed to a fluid matter, not unlike, in colour and taſte, an unrectified oil of vitriol, in which ſtate it continues to this day. There moreover appears in the courſe of the crumbling of this *pyrites*, a circumſtance altogether peculiar and very memorable; namely, that it then

then (moſt of all, that which reſolves the ſooneſt) heaves or ferments, as it were, from within outwards, comes to have cracks, and thus gradually falls aſunder, and acquires a vitriolic ſalineneſs. Whence it clearly appears, ſuch fermentative, inteſtine, diſſolutory motion muſt needs originally ariſe in the very center of the *pyrites*. In the *conchites bivalvæ* of Landwernhage, which are ſtill covered with their cloſe natural ſhells, but internally filled with *pyrites*. I obſerved in what manner, ſome, before ever any thing vitriolic could be obſerved in them, ſnap aſunder in the middle, and open quite wide, in ſuch a manner, as that the hinges, wherewith the ſhells ſtill remained joined together, ſtand directly oppoſite to each other, which can be aſcribed to nothing but the above mentioned cauſe. Further, ſome authors have remarked, the *ſulphur pyrites*, both in the groove and elſewhere, when lying moiſt and heaped high on each other, uſually to heat from within outwards. And in order to try, whether the ſame would not hold of the *pyrites* of Almerode, I took between 50 and 60 pounds thereof freſh dug, and ſtamping them to the fineſt powder, I moiſtened this powder gently, and ſhot it into tall glaſſes, prepared expreſly for the purpoſe; and tho' left ſtanding open for ſome time in the free air; yet it did not diſcover the leaſt degree of heat or warmth: nay, the *pyrites*, thus moiſt and laid high on each other, would not even bewray the leaſt change, or yield the leaſt vitriol: whether the time of year, as it happened to be October, was unfit for this experiment, I ſhall not pretend to determine. This very experiment I repeated in another manner, putting ſmall powdered *pyrites*, moiſtened with brandy, into a low cucurbit, to which I fitted a large helm and receiver, in no caſe

to

to loſe the brandy paſſing over; which even then, without raiſing any degree of warmth in the *pyrites*, began moſtly in the night time to re-diſtil over, though ſlowly, there being, for weeks together, not above half a pint procured: this brandy taſted ſomething of the *pyrites*, and was very phlegmatic; whence I conjecture, not only the bare nocturnal cold, but alſo the inteſtine heat of the *pyrites* to have contributed ſomething to its paſſing over. Be this as it will, thus much at leaſt we may learn from the reſolution and vitrioliſation of the *ſulphur-pyrites*, that in it is certainly included ſomething highly prone to inteſtine motion; and to be ſought for either in the common ſulphur or the iron; of both which we know the *pyrites* conſiſts. The phænomina ariſing from artificial and natural productions, combined with ſulphur; for inſtance, phoſphorus and the bituminous alum ores, which take fire in the open air, and reſolve to alum, ſhould almoſt perſuade one, that the ſulphur ought to be conſidered as the principal cauſe of the vitrioleſcence of *pyrites:* and accordingly I underſtand the matter thus; the inflammable ſubſtance combined with the ſulphur of the *pyrites*, is itſelf by the acceſs of the external moiſt air, not only firſt excited, and then the whole concrete put into motion by it, but moreover is ſtill more and more freed, and at length quite ſeparated from its union with the acid; conſequently, ſuch acid, after a perfect ſeparation, unites with the iron, and forms a vitriol. By way of concluſion, I add that no one, ſo far as I know, has hitherto written of the *vitriol pyrites* of Almerode, nor are there any vitriol-huts there. 'Tis true, the alum-boilers prepare from their lie, precipitated by means of urine, a green vitriol, but

but ſo poor as to be ſold very cheap, it being but little valued. Thus far M. Roſinus.

II. The ſpecific gravity of the PYRITES.

As I myſelf was without a good hydroſtatical balance, I in this caſe applied to the celebrated Dr. Meuder, who readily gave me his aſſiſtance here, and not only examined the *pyrites* and its concomitant matters in the moſt accurate manner poſſible, and with repeated care and diligence, but alſo many others, and thoſe the principal, both denſe and fluid bodies, as laid down in the following tables; to which he has ſubjoined a ſet of uncommon remarks and principles, and peculiar ways of managing the hydroſtatical ballance. The ſmall table of *pyrites*, ſulphur, arſenic, &c. might have ſeemed ſufficient for my purpoſe; but as this is a ſubject hitherto not ſo fully and fundamentally examined, the reader will not be diſpleaſed if I give the tables at length; the ſpecific gravity of the *pyrites*, and its concomitant matters deſerving the utmoſt regard, and a ſubject being ever beſt illuſtrated by compariſon with other matters. Dr. Meuder goes on thus.

As the ſpecific gravity of each body is deemed to be one of its characteriſtic marks, and as ſuch obſervations may be ſuppoſed of further phyſical uſe, we have given the following tables of the ſpecific gravity of the principal and moſt known mineral bodies.

1 Tranſparent amber.
2 Colophony.
30 Brown pitch.
43 Black pitch.
111 Aſphalum.

244 Pu-

244 Pumice-ſtone, full of water.
274 Stone-coals.
296 Gum-arabic.
418 Aphronitrum.
430 Hard gypſum, full of water.
438 Red tartar, full of water.
533 Crude ſulphur.
545 Purified ſulphur.
546 Foſſile opal.
556 Sulphur, once melted over.
556 Foſſile ſulphur.
559 Stone-marrow, or lac lunæ, full of water.
559 Crabs-eyes, full of water.
568 Brown glimmer.
601 White Indian porcelane.
611 Facitious black-lead.
616 Sweet vitriol-earth, out of the Minera martis Haſſiaca.
618 Cat-ſilver.
624 Lapis ſpecularis.
630 Bricks, full of water.
630 White miſnian porcelane.
635 Red Japan porcelane, full of water.
639 Cryſtal-glaſs, of burnt flint and ſaltpetre, equal parts.
642 Stone from the Prudel, at the Carlſbad.
648 Chalk, full of water.
658 White Bohemian glaſs.
661 Variegated glitter-glaſs.
668 Red coral.
669 Common blue glaſs.
674 Red bole, full of water.
676 Green glaſs, with one eight verdegreaſe.
677 Amianthus from the Serpentine quarry near Zoblitz.
678 Alabaſter.
679 Dreſden cryſtal-glaſs.

680 Oblong

680 Oblong belemnites, full of water.
680 Horn-ſtone.
681 Ophites, or ſerpent-ſtone.
681 Coral-ſtone.
684 Lapis Lyncis.
685 Stone from the vineyard, from Malaga.
685 Cornu Ammonis.
687 Hungarian marbled diamonds.
689 Druſiform mountain-cryſtal.
690 Ruby-glaſs.
691 Chalcedon, near Zwickau.
692 White marble.
693 Martialiſed oak-wood.
695 Agat.
695 Quartz.
696 Elbe flint-ſtone.
697 Cologne chalk.
698 Red jaſper.
699 Pietra di Venturino.
699 Mother of pearl.
705 Shiver-ſtone.
705 Sulphur ſlags.
707 Black ſoft grind-ſtone.
709 Red marble.
709 Blue iron-ſlags.
713 Lime-ſtone.
716 Ætites.
718 Quartz, near Rudelſtadt, in which there is native gold.
722 Soft ruddle, full of water.
726 Violet-ſtone.
727 Alumen plumoſum.
738 Granate-ore, near Pirna.
759 Razor-hone, ſoft and white.
771 Red arſenic, or ſandarach.
781 Foſſile verdegreaſe, or chryſocolla.
784 Highly red ſandarach.

785 Dingy

785 Dingy ſandarach.
796 Cadmia fornacum, for braſs.
807 Orpiment.
813 Iron-ſcales.
821 Smelted luna cornua.
827 Foſſile black-lead.
828 Lapis de tribus.
833 Yellow arſenic.
834 Magnet, full of water.
837 Small granates.
838 White arſenic.
841 Pyrites from the Croner.
843 Yellow pyrites, from Lorentz.
844 Ordinary, or poor cadmia fornacum.
848 Blend, or mock-lead.
849 Copper-ore, from Temeſwaer.
854 Ceruſs, full of water.
858 Hungarian copper-ore.
858 Common antimony.
861 Copper-ore, near Rudelſtadt.
863 Yellow pyrites, from Neuſtadt.
863 Large granates.
863 Ore of antimony.
864 Cloſe black iron-ſtone, from Kuhnheyde.
865 Yellowiſh pyrites, from the Hartz.
870 Blendy, or mock-leady cadmia fornacum.
871 Tinny black-lead.
873 Pyrites-balls, from the Andreaſberg.
883 White ſpath, from the Seegen-Gottes.
884 Toplitz pyrites.
891 Pyrites from the Geyer.
892 Pyrites from Temeſwaer, full of water.
895 Snail-cobald from Schneeberg.
897 Bohemian granate-ore.
900 Blood-ſtone, or glaſs-head.
905 Pretzſchendorff pyrites.
906 Factitious fly-ſtone, full of water.

907 Yel-

907 Yellowiſh pyrites, from Johan-Georgen-ſtadt.
907 Yellowiſh pyrites, from the Halſebrucke.
908 Yellow pyrites, from Sweden.
912 Minera martis Haſſiaca.
914 Yellowiſh pyrites, from Sweden.
915 Glaſs of antimony, made *per ſe*.
916 Yellowiſh pyrites, from the Ehrne-ſchlange.
917 Yellowiſh pyrites, from the Zug.
919 Cloſe, or firm pyrites from Temeſwaer.
924 Hungarian quickſilver ore, full of water.
940 White pyrites, from the Himmels-farth, and Gunther.
945 Glaſs of lead.
955 Cinnabar, fixed with ſilver-filings.
956 Teſtaceous-cobald, or foſſile fly-ſtone.
959 Smalt-cobald, from the Seegen-gottes.
962 White pyrites, from the Kuhſchacht.
966 Tranſparent red-goldiſh ore.
968 Smalt-cobald, from Schneeberg.
975 Glaſſy ore.
976 Biſmuth-ore, dove-necked.
978 Regulus antimonii ſtellatus.
980 Repeatedly purified regulus of antimony, with twice the quantity of iron.
989 Tin-ſtone.
990 Clear lead-glitter, or galena.
991 Cobald, near Rudelſtadt.
993 Zink.
993 Regulus of antimony, with twice the quantity of copper.
993 Snail-cobald.
997 Coarſe lead-glitter.
997 Fine tin.
999 Coarſe mineral cinnabar.
1001 Common, or alloyed tin.
1002 Kupffer-nickel.

1003 Mi-

1003 Mineral cinnabar in grains.
1003 Speiſe from lead-work.
1004 Druſiform lead-glitter.
1005 Diced lead-glitter.
1006 Factitious cinnabar.
1007 Iron.
1009 Silver-litharge.
1013 Speiſe, of four parts zink, and one part copper.
1022 Braſs.
1022 Malleable prince's metal, of copper and cadmia fornacum.
1026 Silver alloyed ſix parts.
1028 Copper.
1029 Biſmuth.
1046 Silver.
1058 Villach lead.
1073 Quickſilver.
1098 Gold.

Remarks on the HYDROSTATICAL BALANCE, and its uſe.

I. For a balance to be ſenſible and accurate, that is, conſtantly to ſhew, in an uniform manner, the ſame degrees, the ſtem muſt be hollow and open a-top, for the air in the body below to have a conſtant free communication with the external air.

II. Conſequently, ſuch are unfit whoſe ſtems are either not hollow, or yet are cloſe a-top; as the common glaſs and amber ſort.

III. The longer the ſtem, the better; as then the greater number of degrees may be marked thereon, and the more different bodies it can bear, without ſinking down.

IV. The

IV. The ſtem muſt alſo be of equal thickneſs and ſtrength throughout, otherwiſe it ſinks not down ſtraight, proportionally to the weights applied.

V. The beſt figure for the lowermoſt body of the balance is the conical, as ſuch, may with leſs reſiſtance force through the fluid.

VI. The lines, or degrees on the ſtem, muſt be made accurate and equal to each other, and one tenth of an inch is a proper meaſure, or ſtandard to divide by.

VII. To the cone, or belly below, there is a perforated ſcale of a balance appended, for the fluid to paſs through, and thus the true degree of gravity not to ſuffer any alteration. Theſe ſmall perforations, however, have not hindered the weighing of running mercury, without the leaſt of it ſtraining through.

VIII. The very balance wherewith the above remarks were made, has a ſtem of nine inches, each divided into ten parts, making in all ninety diviſions; with one grain of fine ſilver, it ſinks ſix lines, conſequently bears in all (from one to a ninetieth degree) only fifteen grains; whereas my amber ſtem, eight inches long, and containing eighty lines, ſcarce ſinks one line with one grain of ſilver; and thus the firſt is ſix times more ſenſible than the ſecond. A grain I call the ſixty fourth part of a drachm, namely, the piece which is marked with ſixteen ſtandard penny weight.

IX. A difficulty ſtill attending a balance ſo ſenſible is, (as then it muſt be ſenſible for the obſervations) that very few bodies can be weighed by it; for the moſt either quite ſink the balance under water, or leave it quite a-float a-top, ſo as not to ſink at all; as, among all the above bodies, ſcarce ten have, barely of themſelves, ſhewn their degree of gravity. But this difficulty may be eaſily obviated, by correcting the levity and gravity, by the adding and taking away of weights, and then calculating how many degrees ſuch weights make out, and how much muſt be added or deducted.

X. The fluid wherein you weigh muſt be conſtantly one and the ſame, alſo be of the ſame degree of warmth, or of cold; whence, in winter, the degrees appear not the ſame as in ſummer, even though the very ſame water be uſed.

XI. The degrees on the above balance muſt be counted from below upwards, as theſe muſt encreaſe with the encreaſe of gravity.

XII. All the bodies you would weigh are previouſly, by means of a pencil, to be wetted with water; otherwiſe the air-bubbles adhering to the body under the water, make it lighter than it is.

XIII. Alſo all porous bodies, as crabs-eyes, chalk, *&c.* muſt be ſuffered to abſorb their fill of water; elſe alſo the body proves lighter than it really is.

XIV. In regard to artificial, and other bodies, care is alſo to be had, that they contain no included

cluded air, which cannot be diſcharged; as is often the caſe with caſt ſulphur, and alſo the *ætites*.

XV. At laſt, all the bodies muſt be weighed, in the moſt accurate manner, on an aſſay-balance of equal weight, one grain thereof anſwering exactly to ſix lines: all bodies, weighing three drachms, have, for the above obſervations, been weighed with the utmoſt accuracy.

XVI. But for examining the comparative gravity of ſalts, as alum, borax, vitriol, ſal-gem, *&c.* inſtead of water, rectified ſpirit of wine is to be uſed, as not diſſolving therein in the courſe of the weighing.

XVII. In order to weigh a coſtly body, of which a heavy piece cannot be had, or if too heavy, none of it can be ſtruck off, look in the table for a body approaching tolerably near to it in ſpecific gravity, and of this laſt weigh, on the aſſay-balance, an equal weight againſt the coſtly body; then weigh both in water; laſtly, add to or ſubſtract their difference from the known body in the table, according as the coſtly body happens to be lighter or heavier, and you procure the true ſpecific gravity of the coſtly body, by the proportion in the table.

A curious and uſeful contrivance for ordering a tall cylindrical glaſs in ſuch a manner, that upon pouring into it an unknown ſaline water, the hydroſtatical balance ſhall inſtantaneouſly, without a calculus, ſhew the number of grains or drachms of ſalt in a pound of the ſaline water.

(1.) Cauſe to be made a tall cylindrical glaſs, about twelve inches high, and two and a half thick;

(2.) fill

(2.) fill it up with running water; (3.) append to the cone of your balance ſo much fine tin as ſhall ſink nearly under, yet with its uppermoſt point appear above the water; (4.) mark the place on the glaſs, where the upper edge of the cone ſtands: (5) now diſſolve in four pounds of ſuch water, one loth, or half an ounce of common ſalt; (6.) with the ſalt-water fill the cylindric glaſs to the preceding height of the common water; (7.) hang your balance therein, as before, and when it comes to reſt, mark again, where the upper edge of the cone ſtands below; (8.) divide the diſtance between the two points marked, into ſixty equal parts (each of which is to ſhew a grain) and write the numbers from below upwards; (9.) and thus the balance will, with its upper edge, ſhew the number of grains of ſalt in a pound of each ſaline water, upon filling therewith the cylinder: (10.) but if the balance refuſe to ſink, 'tis a ſign there is not above a drachm in one pound of the water: hence mixing one pound of the ſaline water with one of common, and then, in the manner above, examining this weakened water, and doubling the grains found, you again procure the true *yield* of ſalt.

The gravity of different fluids compared.

300 Rectified ſpirit of wine.
332 Pontack.
333 The Weiſeritz-water.
333 The Wolckenſtein bath-water.
333 Rheniſh wine.
334 The Radeberg bath-water.
334 New Miſnian wine.
335 The Freſs-water, near Graupen.
336 The cold Caroline Prudel-water.
357 The cold Caroline Muhl-bath-water.

339 The

339 The Zedluſch bitter water.
341 The ſound urine of ſanguine conſtitutions.
343 Cow's milk.
343 Dreſden beer-wort.
344 Dreſden double beer.
348 Aſſes milk.
361 Red Miſnian muſt.
374 Common ſpirit of ſalt.
378 Common ſmall *aqua fortis.*
391 Common good *aqua fortis.*
516 Oil of tartar, *per deliquium.*
606 Common oil of vitriol.
4500 Quickſilver.

But as at preſent our principal view is to the *pyrites*, we ſhall bring it, in its kinds and appendages, with a reduction of the numbers, into the following table apart.

1 Crude ſulphur.
12 Purified, or common ſulphur.
23 Foſſile ſulphur.
23 Once-melted ſulphur.
172 Sulphur-ſlags.
251 Red arſenic, or ſandarach.
274 Orpiment.
295 Lapis de tribus.
300 Yellow arſenic.
305 White arſenic.
330 Yellow pyrites.
375 Yellowiſh pyrites.
423 Foſſile fly-ſtone, or teſtaceous cobald.
429 White pyrites.
435 Smalt-cobald.

Thus far Dr. Meuder.

We then ſee how *pyrites*, and its ſulphur and arſenic, compared together, and with other bo-

dies, ſtand related in ſpecific gravity; and by this means not only learn to diſcover the nature of the reſpective bodies: for inſtance, that arſenic approaches extremely near to the nature of metals. We are alſo hereby furniſhed with a teſt to judge of the relation between this and other bodies in the firſt table, which may be ſafely depended on: for thus, a ſulphur, the more arſenical it is, the heavier; an arſenic, the more ſulphureous, lighter than a white cryſtalline arſenic; and an orpiment muſt contain more of arſenic than of ſulphur; a *pyrites*, and an *arſenic pyrites*, the heavier, the more arſenical, *&c.* Only it is well to be obſerved, (1.) that the body to be examined have not the leaſt foreign admixture, as ſtone, earth, or other ore adhering; (2.) be not fibrous and porous, but cloſe or denſe, for the air not to lodge entangled in it, or, notwithſtanding, being capable of being exhauſted, as both theſe circumſtances render the proof fallacious. This, for inſtance, is the reaſon why crude ſulphur appears lighter than purified ſulphur; whereas crude ſulphur, when of a grey caſt, as this was, and generally is, holds a little arſenic, and though never ſo little, it muſt at leaſt preponderate purified ſulphur. Further, foſſile ſulphur weighs more than purified ſulphur, the latter not being ſo cloſe or denſe as the former; whence that ſort melted once more over, and thereby becoming cloſer, is heavier than the purified. Yet cloſeneſs, or denſity and gravity go not always hand in hand; flint, for inſtance, is lighter than quartz, and this much lighter than ſpath: white cryſtalline arſenic is much lighter than foſſile fly-ſtone, which ſublimes entirely in form of a white arſenic, whence the cryſtalline arſenic muſt either have acquired or loſt ſomething, which muſt needs have made it lighter. Nor need we wonder that yellow, or copper *pyrites*,

is

is lighter than yellowiſh, or iron *pyrites*, though the latter conſiſts only of iron and ſulphur, but the former of copper and arſenic (at leaſt more than the latter) which are heavier than iron and ſulphur; and from this we muſt needs conclude *copper-pyrites* to hold more unmetallic, conſequently more light earth. But, to ſay the truth, the hydroſtatical balance is far from being that abſolute means of attaining to the entire and full knowledge of bodies, which ſome philoſophers, who might be too nice to ſmut their hands with chemical proceſſes, would have us to take it for, whatever ſhort auxiliary means it may otherwiſe be: nay, nor this balance, nor the fire alone, nor air, nor depart-waters alone, nay, often, not all of them together are ſufficient to diſcloſe to us the ſecrets of nature.

III. *Miſcellaneous Obſervations and Experiments on the* PYRITES.

I. Native ſilver is moſt commonly found either in pure quartz, or near and on cobald, and conſequently on an arſenic-ore; though *miſſpickel*, or *arſenic-pyrites*, equally with cobald, be arſenical, yet we have hitherto had no inſtance of native ſilver thereon, which muſt be owing to its iron, or other earth, hindering the production thereof.

II. Native gold is, in like manner, commonly found in pure quartz, never on cobald; whereas, on the contrary, 'tis to be found on *miſſpickel*.

III. On yellowiſh and yellow *pyrites* we find nor gold nor ſilver, at leaſt, not as growing from ſuch *pyrites*.

IV. I have been lately ſhewn a ſample of *kneiſs* with yellowiſh *pyrites*, and capillary ſilver lying thereon, as if the ſilver grew from the *pyrites*; but

firſt, it follows not hence, that becauſe it lay on, it therefore proceeded from it: again, though we ſhould allow this, yet it muſt needs be aſcribed to the arſenic, this *pyrites* being hemiſpherical, and thus arſenical, like what we call *cobald*, at the Halſebrucke.

V. Nay, this ſample would ſeem to ſhew, that the native ſilver comes to be *weathered* or deſtroyed again. 'Tis true, this I cannot conclude from the ſooty appearance, which, though in itſelf of ſome conſequence, yet is not to be depended on, as this or the like ſample would require an obſervation of many years; as, whether in that time the ſilver may be deſtroyed again, and in what manner; at leaſt, 'tis a thing not readily credited by every one; and the crumbling and falling to pieces of the ſample, is well to be diſtinguiſhed from its *weathering*.

VI. Should native ſilver happen to be *weathered* again, it muſt needs be arſenical; in the manner it is affirmed, that native gold is often mercurial, and thus pale.

VII. It is true, *pyrites* is the mother of vitriol, but neither the mother, nor a recrement of metals, as was formerly thought *, but an ore *per ſe*.

VIII. As to what is ſaid of the exiſtence of gold in an Hungarian vitriol, communicating itſelf to the depart-water prepared therewith, it proves a ſelf deception, ariſing either from the experiment, or the judgement formed upon it: for, though the mint-maſter in Becher had found gold in it, it would neither be a fixation, nor an extraction, but a production, rather of a thing exiſting in neither of the matters employed, but produced from both †.

IX. Cane-

* Canepar. Deſc. I. c. 2. Ludov. de Comit. de Met.

† Tollii Epiſt. Itiner. V. p. 175. Becher. Phyſ. L. 1. Sect 3. c. 3. p. 142

IX. Caneparius § pretends to have ſeen with his own eyes, rubbed marcaſite, or *pyrites* changed, by pouring on vinegar, to quickſilver; which well agrees with what I adduced above from Boyle, at the cloſe of chap. XIII.

X. Pomet was aſſured, a certain abbot had, from a certain marcaſitical vitriol-yielding *pyrites*, to be found in the clay-earth near Paſſi, a mile from Paris, prepared his *univerſale*.

XI. That *pyrites* is of a mercurial nature, Albertus affirms may be concluded from its giving to copper a white colour ‖.

XII. Matheſius mentions a marcaſite holding quickſilver and an arſenic ore (cadmia) from which, upon ſtriking, there ſquirted out quickſilver §§.

XIII. How to draw quickſilver from vitriol, ſee Caneparius. ††.

XIV. Calx of lead digeſted with ſal ammoniac, ſalt of tartar, and ſtale urine, and at length diſtilled, yields an arſenical odour, nay, at laſt, a beautiful phoſphorus.

XV. I have had from Neuſol, in Hungary, a white ſalt, under the appellation of a white vitriol, there called *ſtrep*, of an oblong, tender, cryſtalline form.

XVI. The Radberg-bath comes from a *pyrites* extremely pure, above all other groove-*pyrites*, in iron vitriol.

XVII. In Sweden, in the large copper-groove at Fahlun, there was found, as Leyel ** relates, a man's body, which had lain there for forty years at

§ De Atrament. Deſcr. I. c. 10. p. 63. It. c. 18. p. 108.
‖ Ludov. de Comitibus de metallis, p. 236.
§§ Libavius de natura metall. Lib. I. c. 1. p. 7.
†† P. 218.
** Acta Lit. Suec. Trimeſtr. prim. an. 1722. p. 250.

leaſt, not only fleſhy, uncorrupted, and ſweet, but alſo ſheathed, and done all over with vitriol, in manner as if candied.

XVIII. But to ſee how corroſive things, as vitriol, which deſtroy not, nay, rather preſerve dead bodies, are more active and operative on living ones, we need only recollect what is practiced by the Eaſterns, who ſhave themſelves with a mixture, conſiſting of crude earth and orpiment; yet, if care be not had, come to have their fleſh perforated, or their ſkin become like Cordouan leather ***.

XIX. To try the effects of vitriol on vegetables, I diſſolved vitriol in water, wherein I ſoaked ten grains of barly for twenty four hours, then letting them dry, they became quite black. Of theſe no more than two came up, with very weakly ſtalks, and ſmall ears. Whether this was owing to the vitriol, or the great degree of drought, having planted them a little too late, I know not; yet vitriol appears to have but little fruitfulneſs in it, eſpecially from the vitriol-earth at Rogau in Sileſia, which being at firſt employed as a manure, rendered the fields barren *.

XX. Dr. Gould, of Oxford, has obſerved, that oil of vitriol does, by means of the air, encreaſe in weight, having, for that purpoſe, expoſed a highly dephlegmated oil in an open wide glaſs, and weighed it accurately every day. In the ſpace of fifty ſeven days, three drachms of oil of vitriol came to nine drachms, thirty grains. The firſt day the oil increaſed one drachm and eight grains, afterwards, from day to day, ſtill leſs, nay, the laſt day, ſcarce half a grain. This ſucceeds in moiſt foggy weather better than in dry, alſo in a wide than narrow veſſel †. XXI. To

*** Tavernier's voyages, p. 166.

* Breſsl. natur-und. medicin-geſchichte im jahr, 1718. Jul. p. 1402.

† Phil. Tranſ. N° 156. p. 496.

XXI. To ſhew the volatiliſation of metals, Mr. Boyle alledges the following experiment: if you diſtil thin copper-plates with an equal, or twice the quantity of mercury ſublimate, there remains ſomething below, running, and inflammable, like Spaniſh or ſealing-wax, which being powdered and expoſed to the air, then ſaturated with ſpirit of ſalt; yields ſomething like a verdigreaſe; and this, again, diſtilled with tripoly, or the like, gives a clear liquor, like ſpring-water, which turns green with ſal ammoniac, or a volatile ſalt §.

XXII. Swedenberg has, in a *prodromus*, attempted to diſcover, in a geometrical way, and by the hydroſtatical balance, the nature of bodies; but ſuch concluſions, however, appear to me to be premature, it being neceſſary, firſt of all, not only to repeat and verify ſeveral, but, much more ſo, to make new experiments.

XXIII. In the Salberg-groove, in 1696, ſome running quickſilver was found, but never at any other time; alſo once, ſome in Lapland §§.

XXIV. As I was concluding this impreſſion, I had ſome *pyrites* ſent me from Alonitz, in Ruſſia, of which I ſhall only ſay, that it differs not from other *pyrites*. The copper-ore in the Schiniſelgi-groove, which is laſulous, holds forty five pounds of black copper. At the groove Bogatvi Mednoi Jamii, alſo at the Niniſelgi Knordu, there *breaks* a fine quartz with native copper: and which is very remarkable, in the diſtrict of Nerzinſkoy, in the groove Bajatky, there is found a fine-grained glitter, or galena, containing eighty five pounds of and four loths of ſilver.

XXV. Take one pound of *marcaſita aurea*, ſays Mazotta **, and diſſolve it in two pounds of de-

§ Boyle on the wholeſomeneſs of the air. part-

§§ Leopoldi relatio de itinere ſuecico, p. 81.

** De triplici philoſophia, p. 202.

part-water, to which put four loths of ſal ammoniac, pour off the ſolution, ſuffer it to evaporate, and the *marcaſita* remains at bottom. Take of this marcaſite twelve loths, gold-calx, or leaf-gold, two loths; ſal ammoniac, and mercury ſublimate, of each two loths; pure running quick-ſilver, ſixteen loths; mix all together, and ſublime for ſeven times, or ſo often, till at length all come to remain fixed at the bottom, and each time the ſublimate is again to be mixed with what remains ta bottom: mix this with two loths of ſal-ammoniac, and imbibe it with one pound and a half of the alcali, to be deſcribed below, and the whole will turn to an oil. Give a gentle fire in the furnace called Piger-Henricus, with coals, or with the lamp, for a month, and it will become dry (*congelabitur.*) Of this medicine take two loths to ten pounds of well purified quickſilver, give a gradual fire in a wind-furnace, and let it ſtand for an hour in flux, and it will be fixed to a gold, and tinge copper and ſilver. The alcali for the purpoſe is thus prepared. Pour vinegar on alcali, 'till it come to clot, or bear being made into balls, and let it dry in the ſun, then give a reverberating fire for twenty four hours; rub it fine, and diſſolve it in twice its quantity of diſtilled vinegar; diſtil, cohobate with the very ſame vinegar; diſtill once more, and let it run, *per deliquium*, in a moiſt place, on a marble or glaſs; dry it again, and again run it, the proceſs is to be frequently repeated; and, what is ſurpriſing! it reduces all ſpirits and bodies (*ſpiritus et corpora*) to a water, and is a highly valuable ſecret.—Let who will try it for me, I cannot.

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CORRIGENDA.

PAGE 56. *line laſt*, read *been*.
p. 80, *l.* 19, read *receptive*.
p. 136, *l.* 8, read *centner*.
p. 140, *l.* 4, read *heavy*.
p. 156, *l.* 7, read *act*.
p. 178, *l.* 11, read *confections*
p. 202, *l.* 12, read *it*.
p. 218, *l.* 6, read *illuſtration*.
ib, *l.* 7. read *demonſtration*.
p. 220 *l.* 2. for *rites*, read *pyrites*.
p. 231, *l.* 9, read *effect*.
p. 234, *l.* 26, read *edulcorate*.
p. 276, *l.* 9, read *preferred*.
p. 349, *l.* 28, read *a different, as it*.

FINIS.